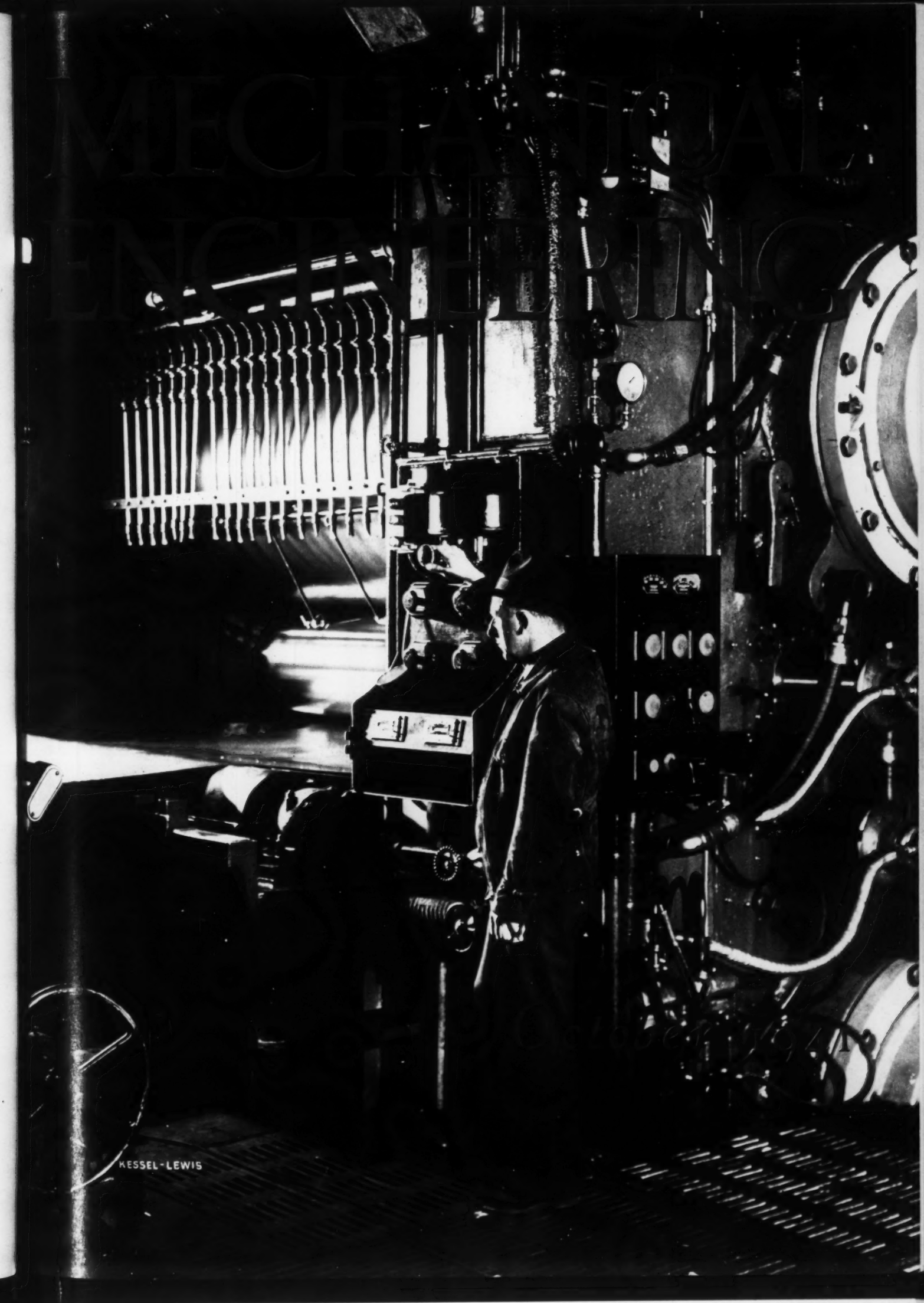
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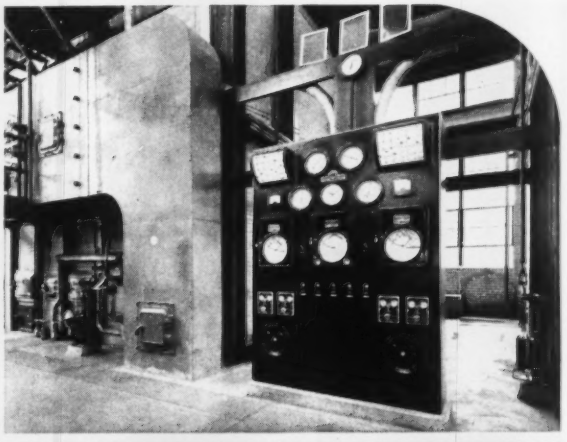

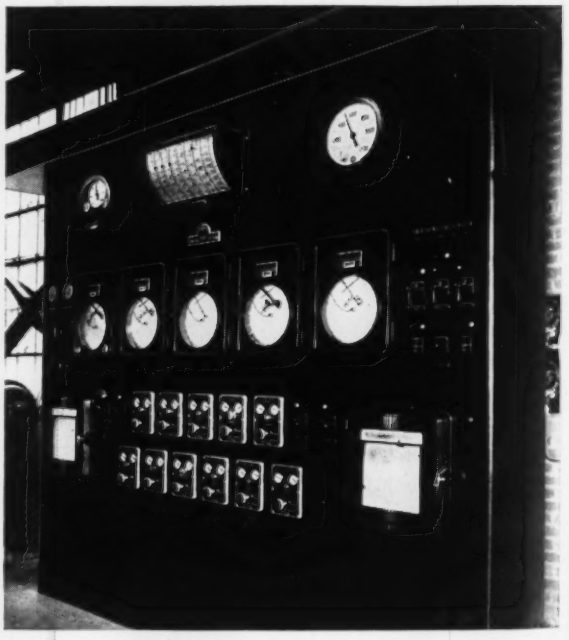

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MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 63 NUMBER 10

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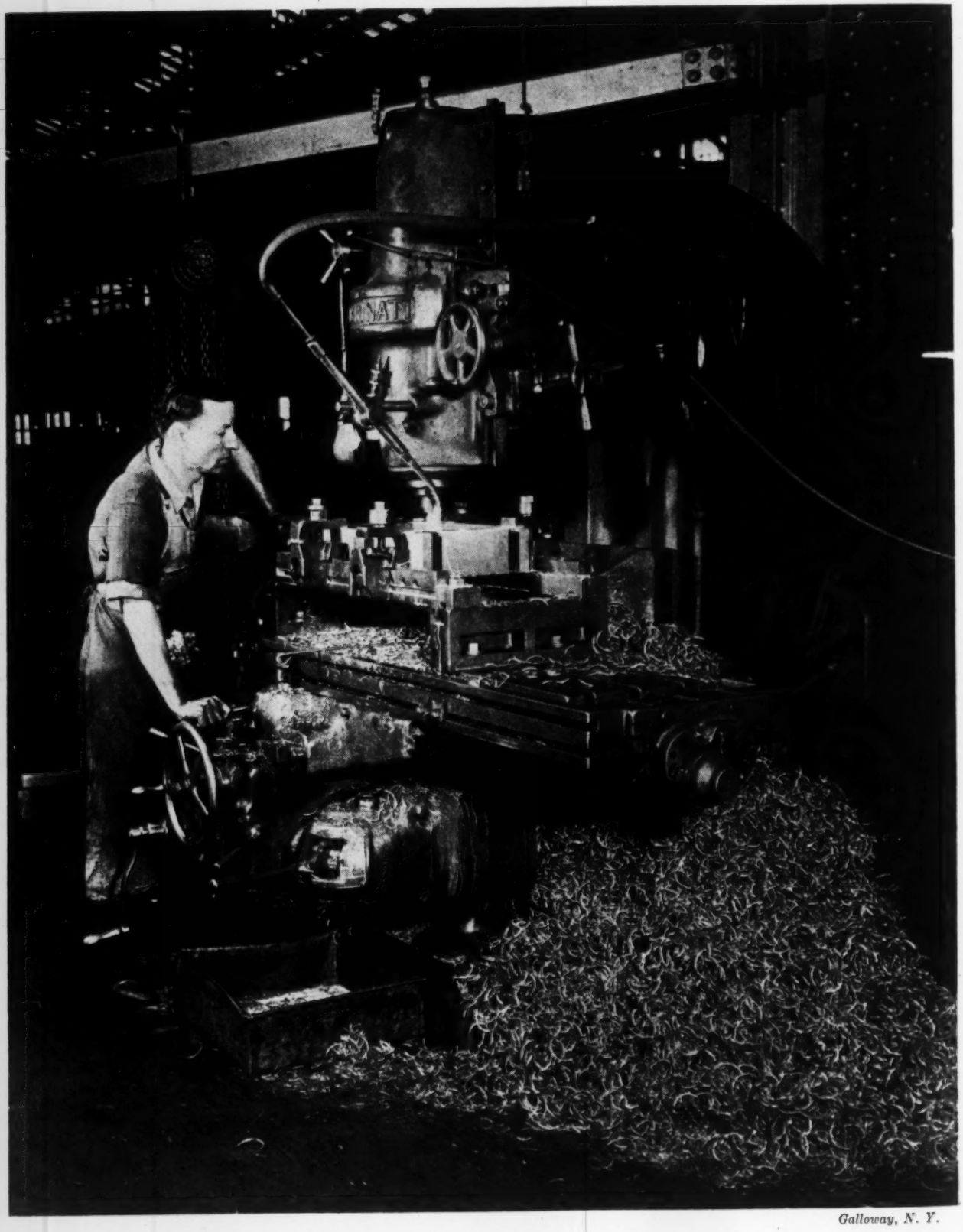

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Men and Machines for National Defense

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No. 10

MECHANICAL ENGINEERING

OCTOBER
1941

GEORGE A. STETSON, *Editor*

Form the Habit Now

OCTOBER witnesses the revival of activities in 120 A.S.M.E. Student Branches with their enrollment of about 7000 men. This is nearly twice as many student branches as there are local sections, and about half as many students as there are members of all grades above that of student member. One might picture every student sitting down with a member on each side of him—one a man under forty, the other older than forty. One of these members would be engaged in some phase of manufacturing; the second in one of the many other fields that mechanical engineers serve. If each man were to talk on the subject closest to his interest, these 7000 conversations would give some indication of the broad, indefinable extent of mechanical engineering. Somewhere in that vast field every one of the 7000 student members would find the spot where he would best fit. In many cases discovery of the right spot would come as a surprise to the man making it.

Lacking any comprehensive report of these imaginary conversations, the young engineer must acquire the habit of gaining what knowledge and perspective he may by keeping his wits about him from day to day. The trouble is, of course, that the interests of the moment obscure the larger horizon and the more significant trends. One's life congeals too quickly to a fixed pattern. Capacity for growth, adaptability to change, acuity of understanding, interpretation of experience must be cultivated. In the development of the careers of engineers, professional societies and technical publications serve this purpose. They provide the postgraduate training of most engineers. If one pays assiduous attention to meetings and publications of these societies, the beneficial effects of the imaginary 7000 conversations will come to him in the course of time.

Take the current issue, for example. In it the wealth and breadth of engineering contacts are indicated. It is a run-of-the-mill issue. Aside from Mr. Bailey's paper, purposely postponed so as to appear during term time, not a single page was planned with student readership in mind. Yet how rich it is in material of interest to young engineers.

The suggestion is offered that every student member spend an evening with this issue and resolve to make it a habit to read subsequent issues. Supplemented with selective attention to the Transactions and with the reading of one or more other technical periodicals devoted to whatever specialty is of greatest personal interest, the habit of reading MECHANICAL ENGINEERING, begun when the practice of serious study is required, will become fixed and prepare the individual for the professional growth without which he cannot hope to make best use of the opportunities and responsibilities that he is bound to face.

One word more. MECHANICAL ENGINEERING is more than a technical magazine. Not only does it have a breadth of coverage, second to none, of an enormous field, but it also lays emphasis on subjects of professional interest in the fields of economics, education, biography and history, social conditions and labor relations, and management of enterprises. It aims to develop the engineer of full habit of mind as well as the technician, and to keep alive the traditions, ideals, and obligations of membership in the engineering profession. Some of the significance of the monthly quota of papers will not appear until maturity and experience provide the background of understanding, but the habit of giving thought to these subjects prepares men for what is to come and builds a profession of high quality.

Shortages

IT comes as a distinct shock to the average American to learn that there are shortages cash and credit cannot make up. But when national abundance is put to the test of all-out defense effort, shortages of all kinds rapidly develop. Fortunately, what money alone cannot do, intelligence and determination can attempt to do. And to engineers intelligence and determination are familiar qualities.

Chief of our shortages is that of time—time to produce and time to mature public opinion. We are trying to do in months what Germany accomplished in years. Mass production makes possible an uninterrupted stream of products in a manner that has the appearance of almost instantaneous creation. But before this stage is reached the long periods of plan and blueprint stage and of tooling up and checking are required before materials flow smoothly from mine to market. Public opinion is powerful and quick to act when consolidated, but it too, even in authoritarian states, must be cultivated. Cultivation takes time and forcing may prove disastrous. There is little we can do about time except to use it intelligently.

Other nonmaterial shortages exist—skill, knowledge, experience, ideals, willingness to sacrifice, unselfish public spirit, tolerance, understanding, unity of purpose, fortitude—qualities which national emergencies demand in abundance. Money cannot buy them. It takes time to develop them.

Shortages of personnel arise because of the increase of demand, the change of its incidence, and the disruption of accustomed routine. We have such shortages that time can cure if training and shift of routine are properly handled. But these too take time. Transportation, communication, power, housing, plant capacity, machinery of production are all called upon for extraordinary service, and in quantities and at locations not foreseen under normal conditions. With preference given to defense projects, what is left over for luxuries and nondefense uses becomes smaller and smaller. Shortages appear where least expected and force us to practices intolerable in times of peace.

Material shortages are hard to understand because we are accustomed to abundance. Yet with all this abundance there is scarcely a commodity that can be procured in the quantity and at the time needed for both defense and nondefense uses. Already these shortages are so acute that plants not engaged in defense work are closing or working at reduced capacity. Workers are thrown out of employment. The demand for certain types of goods cannot be fulfilled. A national crisis is forming. To meet it engineers must exercise their skill and intelligence.

Fortunately, engineers have skill and intelligence to apply to the problem of material shortages. Above all persons they are quick to realize the nature and extent of the emergency. Of all persons they know how to meet it. Individually and collectively they will meet it with well-tried remedies.

First of these remedies is conservation. Brass for the manufacture of shell in the world's largest small-arms ammunition plant will be provided blanked and cupped at the mill to keep as much scrap as possible where it can be immediately remelted. Other examples suggest themselves by the hundred.

Substitution is a natural expedient when material shortages develop. But substitution is too often a vicious circle as one substitute after another fails with increased demand placed on it. Steel eventually bears the burden of most material substitution.

Reclamation affords a means of making use of every idle pound of scrap material that can be made to flow back into production. Provision for the recovery of scrap and cutting fluid is an important detail in the huge aircraft-engine factory described in this issue. But needed materials, particularly steel scrap, are rusting idly in junk yards and on farms, possibly in some forgotten corner of shops clamoring for new stocks. Ways must be devised for starting them to flow back to melting furnaces.

Standardization and simplification of types, sizes, and specifications are typical engineering methods of reducing inventories in storerooms and stock piles. They also release tools, dies, jigs, and fixtures and the time and man power to make them. They ease the burden on some desirable but not strictly essential variations and qualities that become luxuries in times of emergency.

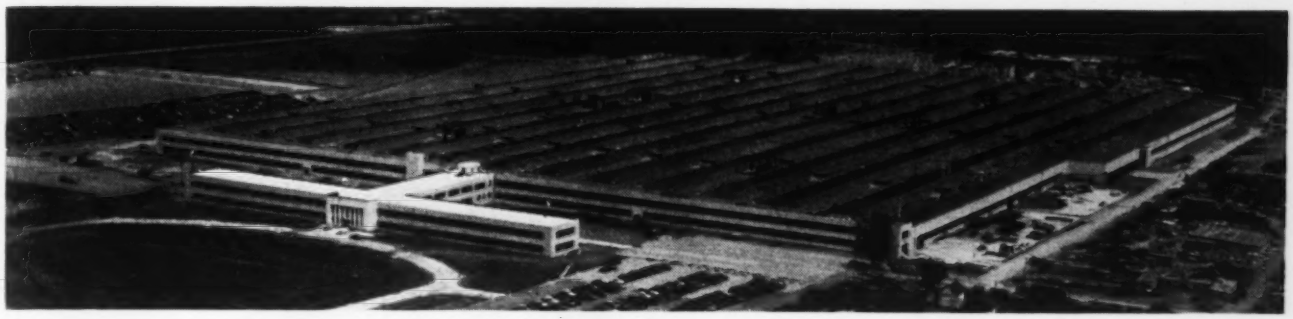
Engineers understand these methods of attacking material shortages, and hence it is to engineers that the O.P.M. has appealed for cooperation in making their knowledge, both general and specific, available to the nation as a whole. The appeal is being made through the engineering societies which have organized an Engineers' Defense Materials Board to exercise leadership in accomplishing the important task of meeting the material shortage. Six organizations, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the Society of Automotive Engineers, and the American Institute of Chemical Engineers, have united in setting up the Board with Robert E. McConnell, chief, Conservation Unit, O.P.M., as its chairman. Their job will be to make every engineer conscious of the threat of material shortages and spur him to devise ways and means of combating them. Leadership resides in the Board, but accomplishment is a matter of individual intelligence and skill, freely exchanged for the common good.

Every engineer can do his part, whether it be in the specific task of meeting the threat of material shortages or in combating the shortages in nonmaterial fields. On individual accomplishment rests the reputation of the engineering profession.

Group Delegates Report

DISCUSSION of problems confronting The American Society of Mechanical Engineers has been carried out for many years under an organized procedure of conferences of local sections delegates at the Annual Meetings of the Society. In recent years this conference has been attended by representatives of groups of local sections, instructions to these representatives or delegates having been the results of other conferences, held during the fall, of the local sections comprising each of the groups. The Group Delegates Conference actions are passed on to the Council of the Society and by that body to the numerous Society committees charged with the activities to which the separate actions relate. These committees render reports to the Council, and at the Semi-Annual Meeting the Council takes appropriate action on every item in the report of the Conference. This procedure affords ample opportunity for the expression of the views of Society members all over the nation, and at the same time assures adequate discussion and consideration of these views by all groups involved.

At Kansas City in June the A.S.M.E. Council took formal action on all business reported to it by the 1940 Group Delegates Conference. In all but a minority of cases the Council concurred in the actions or recommendations of the Conference, and in the few cases where concurrence was not voted, reasons for its decisions were stated by the Council. The document reporting the Conference and Council actions is too long for publication in MECHANICAL ENGINEERING but is available in mimeograph form. Copies have been forwarded to all Society sections and committees. During the coming fall another series of group conferences will be held and the group delegates will meet as usual at the 1941 Annual Meeting in December.



AERIAL VIEW OF MACHINE SHOP AND ASSEMBLY PLANT

(The larger of the two main buildings covers about 35 acres. The front T-shaped part of the structure is the administration building. Adjoining the factory at the rear are the test cells which will total 72 in number when completed. The power house, not visible in picture, is located at the right rear corner of the machine shop.)

THE WRIGHT AERONAUTICAL PLANT IN CINCINNATI

By RUSSELL T. HOWE and ROBERT K. BROWN

CINCINNATI DIVISION, WRIGHT AERONAUTICAL CORPORATION

DURING the late summer of 1939, facilities of the Wright Aeronautical Corporation at Paterson consisted of slightly more than 900,000 sq ft of floor space occupied by both office and factory, in which approximately 5000 persons were employed. Shortly after the beginning of World War II, it was apparent that additional production was necessary and an expansion program was initiated in the local area. The facilities in Paterson have now grown to slightly less than 3,000,000 sq ft of floor area and the company employs more than 19,500 persons in the five New Jersey plants.

With the fall of France and the subsequent introduction of our National Defense Program, it became evident that the productive capacity of this country for aircraft and aircraft engines was far below that which would be required. Because of the multiplicity of operations wherein extensive machining is involved, the aircraft-engine group was among the first to be called upon to expand. Our company was one of the first to be called to Washington to discuss contemplated expansion which was then only a nebulous objective on the far horizon. We were actually the guinea pig in working out the many ramifications for expanding defense production under a government-financed plan.

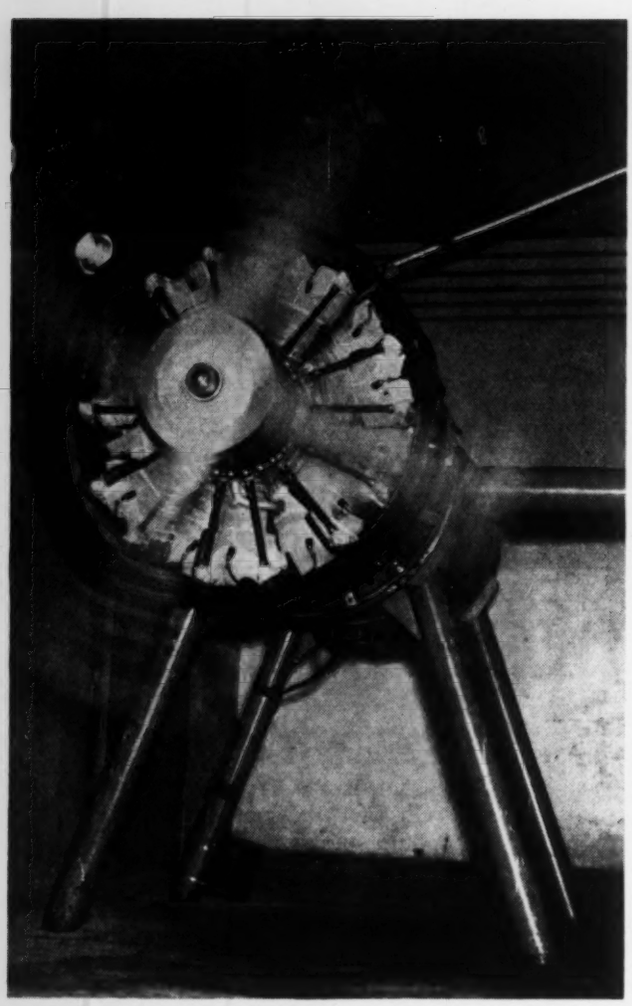
REASONS FOR LOCATING PLANT AT CINCINNATI

One of the government's prime requisites of the program was the location of these factories in the interior, centrally situated between the Appalachian and Rocky mountain ranges. Members of our staff immediately proceeded on survey trips to various cities to determine where this new plant should be located. Cincinnati was selected as the site, first, because it met the government's prime requisite under the expansion program, and, second, because as the center of the machine-tool industry it possessed a wealth of trainable young men.

Contributed by the Management Division, for presentation at the Fall Meeting, Louisville, Ky., October 12–15, 1941, of The American Society of Mechanical Engineers.

Machine tools play a most important part in our operations but as we all know men are required to operate these machines. Our experience in Paterson had proved that a sufficient quantity of trained men to meet the expansion program could not be obtained and that it would be necessary to train operators. Cincinnati offered a background of some three or more generations in the machine-tool industry, wherein the families had been accustomed to earning their living with their hands. The sons of those families represented an abundant source of trainable material—men who had inherited a background of mechanical aptitude and manual dexterity so necessary in the machine operator. The training program, which has been carried on in the Paterson area for a number of years and which was subsequently expanded to meet the growing demand in that area, has been functioning with a high degree of satisfaction. Through the organization of a similar training program in the Cincinnati area we could then draw on this pool of potential operators.

Through the cooperation of the vocational schools in and around Cincinnati, the training program was initiated and has been operating effectively. To augment training further we established a school of our own on the ground floor in our temporary headquarters in the U. S. Playing Card Company, at Norwood, Ohio. Courses were likewise established in the Cincinnati Mechanical and the Cincinnati Aviation High Schools, the Norwood, the St. Bernard, the Lockland, and the Kenton County Vocational Schools, the Middletown Industrial Education High School, and the University of Cincinnati. The American Rolling Mills Company, more commonly known as "Armco," was making some changes in their manufacturing methods and as a result made available some few hundred trainable men. In offering their cooperation, they likewise provided space at their plant for the establishment of a training school similar to those previously mentioned. For those training schools we provided new machinery purchased for our production line so the students could be trained on the exact



CYCLONE 14 TURNED OVER FIRST TIME

(Begins its seven-hour production test run in one of the new sound-proofed test cells. The four-bladed wood propeller is calibrated to absorb the power generated by 1700-hp engines.)

type of machines which they would later operate in the shop. For the Aviation High School, we provided complete engines and a test stand "mock-up" again to duplicate the actual productive operations. All of these training facilities were established during the fall of 1940, shortly after ground was broken for the new plant on October 23.

FIFTY ACRES OF FLOOR SPACE

The Cincinnati plant, designed by Albert Kahn Associated Architects and Engineers, is located on a 219-acre plot just north of Lockland, Ohio, approximately ten miles from the downtown Cincinnati area. The main plant is a single-story structure 1064 ft wide by 1320 ft long and extending across the entire front end of the building is a thirty-foot mezzanine. A two-story structure, 60 ft in width and 160 ft long, connects the main plant with the administration building, which is a two-story unit, 50 ft wide and 500 ft long.

To the rear of the main plant is a battery of 72 test cells arranged in two groups. Both, designed with a central corridor, have a row of test cells down each side. There are 18 test cells in each row, one control room serving two adjacent cells. In the rear of the test cells is located an oil and chip house. Between the two batteries of cells is a covered area which will be used to prepare engines for test. Alongside the lower end of the main plant is the powerhouse. The foundry building and foundry offices are on the far end of the plot. This structure is likewise of the one-story type, measuring 260 by 640 ft. The master substation is also near this point.

The total floor area is 2,120,000 sq ft which represents approximately fifty acres; the main plant covers 35 acres under one roof. To present these figures in a more practical manner, the total area in the main plant is sufficient in size to accommodate six major-league baseball games and four college football contests simultaneously and still provide ample room for 35,000 spectators at each of the ten contests.

To the north of the main plant is a 67-acre parking area to accommodate the automobiles of the 12,000 workers who will function on a ten-hour, two-shift basis. To the south of the foundry is a twenty-acre parking area for the automobiles of the foundry workers. The area between the foundry and the main plant provides sufficient space for doubling the present floor space should this ever become necessary.

Records show that the main plant is the largest single-story structure in the country and it is believed to be the largest in the world. Despite its huge size, all areas have been planned for the expeditious flow of work in process.

100,000 LB OF ALUMINUM ALLOY CASTINGS PER DAY

To describe this production flow in greater detail let us start in the foundry which is devoted to the casting of the aluminum cylinder heads for the Cyclone 14 engines and has an operating capacity of 100,000 lb of aluminum-alloy castings each full working day.

Sand for the molds is stored in bins in a partial basement area. From here it is carried in a series of buckets on an electrically operated monorail to any of four similarly operated skip hoists. This allows one operator, standing at the bins, to load the cars and a second operator, standing at the skip hoists several hundred feet away, to unload them. The skip hoists deliver the sand to the mixing and distribution equipment which is elevated from the floor. It is then delivered to the core room below.

The cores for the cylinder heads are made on 72 individual bronze patterns shaped to conform with the exterior of the head. The interior of the dome and the rocker boxes are formed by separate pieces which fit together before pouring. From the core rooms they proceed to the ovens, each of which is equipped with a 1200-ft conveyer for continuous movement from the benches through the baking operations. After cooling they are minutely inspected, cleaned, sprayed, and passed through a conveyer type of oven, then stored on roller-bed conveyers which automatically carry the cores to the assembly benches.

After assembly the molds are moved on roller-bed conveyers to the pouring zone which is completely hooded and exhausted of all fumes. Melting is accomplished by twelve 1000-lb tilting-type oil-fired furnaces of the same general design as those used in our foundries in the Paterson area. Shakeout and cleaning are done by hand, while heat treating and aging are accomplished in electrically heated endless-conveyer-type furnaces. Wherever possible hand operations have been replaced by mechanical methods. From the time the sand for the molds is dumped into hoppers on a private railroad siding, until the cylinder head is ready for final machining, consecutive operations are executed on a straight-line production basis.

This holds true even to the sand reclaiming process which is entirely different from that previously designed for aluminum foundries. When the castings have been removed, the sand, wire, and refuse are put through two large electrically driven jaw-crushers, after which the metal is removed by means of a magnetic conveyer and returned to the floor level for sorting of the reinforcing wires and nails; the wire being salvaged for

reuse in the core shop. The sand is elevated to a large 60-ton bin and fed by gravity through a series of screens and elevators to a rotary kiln. Later in a cooler of special construction the temperature is reduced. Flowing from this cooler is a pure white beach sand from which all the oil, carbon, and other added elements have been completely removed. It is then classified by means of air into grain sizes and returned to the bins on a continuous rubber belt. Reclaiming of metal from the gates, risers, and other salvageable material from the heads is handled in a double reclaiming furnace of a standard type.

The foundry cafeteria and foundry offices are maintained at a predetermined temperature during the summer by means of a 40-ton refrigeration plant distinct from the air-conditioning unit in the main plant. The foundry proper, the lockers and washrooms, and the lounge room are not air conditioned but are provided with the latest in ventilating equipment. The ventilating equipment is not of the exhaust type but of the pressure type which supplies up to 1,000,000 cu ft of air per minute to these areas.

GREENLEE SPECIAL-PURPOSE MACHINE

(The Greenlee machine is representative of some of the special-purpose machinery built for the Cincinnati plant. This particular unit for machining supercharger front housings cuts production time from 224 to 24 minutes and replaces eight ordinary machines formerly employed in completing the various operations.)

When the foundry operations on the cylinder-head castings have been completed the castings are trucked to the main plant. Here along with other engine parts they flow progressively along rows of machines through the various departments all of which have been laid out for the highest efficiency according to the latest in-line methods of mass production.

IN-LINE PRODUCTION IN MAIN PLANT

Generally speaking, the flow of production will be from rough stores located under the mezzanine at the front of the building, toward the rear of the building. The parts will pass through final inspection, finished stores, assembly department, and final test, and thence to packing and the shipping department.

As an example, one line of machine tools handles cylinder barrels exclusively. Rough forgings start at one end, pass directly from tool to tool down the length of the line, and emerge as finished cylinder barrels. In other sections of the plant cylinder heads, gears, cams, supercharger housings, rear covers, nose sections, and other parts move down the length of the big floor, each part in its own separate line headed for the assembly floor and being completely finished en route.

Certain major parts are likewise manufactured by cooperating vendors where facilities are being utilized under the emergency program. The crankshafts are fabricated by The Ohio Crankshaft Company, the crankcase main sections by the Otis Elevator Company, the propeller shafts by the Eaton Manufacturing Company, the articulating and master rods by the Graham-Paige Motor Company, and the pistons and rockers by the Hudson Motor Car Company. All of these items are shipped completely inspected and ready for delivery to the assembly floor.

Many of the tools for the Cincinnati plant have been specially designed—tools which never before have been used in aircraft engine production for the simple reason that the quantity of engines required did not warrant their cost. However, now that we have large quantities, special machines and machine tools have been designed which represent the accumulated skill of twenty years in manufacturing air-cooled aircraft engines plus the two years' experience gained in war emergency expansion—a two-year period in which the total production output in horsepower has increased 600 per cent.

With the large quantities of engines and the lack of skilled personnel, the skill has been built into automatic and semiautomatic tools thereby permitting the opening of a major manufacturing unit by utilizing semiskilled men trained within a period of a few weeks.

HIGH-PRODUCTION AUTOMATIC TRANSFER MACHINE

The best example of the high production of the automatic type of machine is a special transfer machine for drilling, countersinking, reaming, and tapping aluminum cylinder heads. Eighty feet long and built in two sections, this machine replaces 40 ordinary machines and yet requires only 24 semiskilled operators on a "round the clock" basis as compared with 105 highly skilled men needed on the 40 machines replaced. The first unit of the machine has 16 stations and 25 separate machining operations are performed with 64 tools. The second unit has 56 stations and 46 operations are performed with 70 tools. The machine will turn out a finished cylinder head every 45 seconds as contrasted with the 32 minutes required by ordinary methods. The operators have only to insert

GROUP OF TRAINEES SHOWN IN COMPANY'S SCHOOL IN BASEMENT OF TEMPORARY OFFICES AT NORWOOD, OHIO

(Wright's Cincinnati training program was recently cited by the Office of Production Management as a recommended training system for defense industries.)

the cylinder heads at station No. 1, remove them at the final station, and watch a control panel which instantly indicates if anything is wrong at a given station.

Another example of automatic quantity production is a special machine likewise in two units; the first for rough and the second for finishing the supercharger front housing. These two machines cut down the production time from 224 minutes to 24 minutes, a combination which requires only one skilled operator per machine each shift, as compared to the eight required to operate the eight ordinary machines formerly used.

PLANT AND OFFICES AIR CONDITIONED

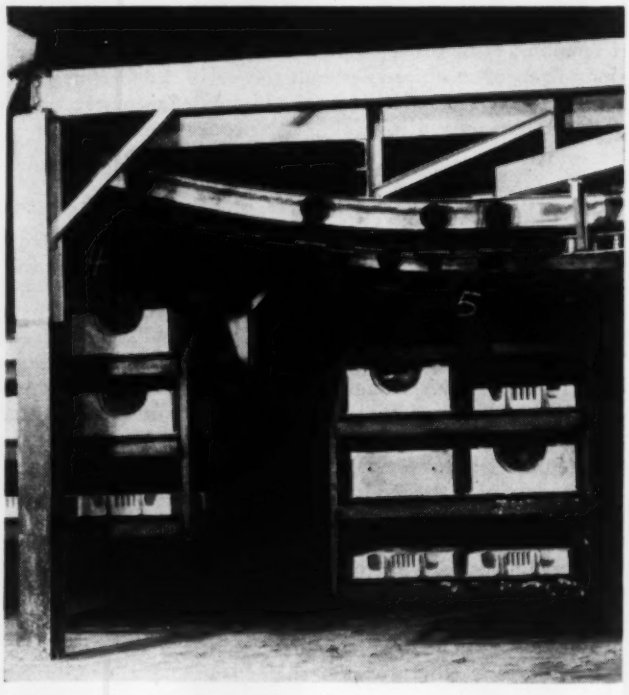
To provide comfortable working conditions, the entire main plant and offices are air conditioned. The air-conditioning system, according to the several firms whose combined facilities were required for its fabrication, is not only the largest ever installed in a single building but is unique in its construction. The air-conditioning plant will have a capacity equal to that of an ice plant producing 12,000,000 lb of ice every 24 hours. Through the installation of the system, it is expected to maintain the aircraft workers' high degree of efficiency throughout the hot summer months experienced in the Ohio Valley area. The system is unique in that it is combined with the heating system of the plant—either hot or cold water can be pumped through the same pipes. For heating, the system is augmented with a series of radiators located around the outside walls. This auxiliary wall heating system will facilitate stabilization of temperature throughout the plant. In the summer the cooling system utilizes the boiler capacity idle during that season of the year. A battery of five centrifugal refrigerator compressors (1200 tons each) are driven by steam turbines using steam from the boilers of the heating plant. These are the largest centrifugal compressors in use at the present time. This procedure saves approximately $100,000 in construction costs. A mechanical refrigeration system will be utilized. The system is so large that the main line, carrying either the hot or chilled water into the factory, is 20 inches in diameter.

The cooling water is continually recirculated so that the air-conditioning system requires only a small amount of make-up water. Hence it is not a burden on the natural underground water reservoir which forms the source of water supply for the factory. To supply the water requirements of the plant, six 1000 gpm deep wells have been installed. All the water will pass through a lime-soda cold process softener where the hardness will be reduced from an average of 600 ppm to 150 ppm. Water for domestic purposes will pass through pressure filters. The service water system is provided with a 350,000-gal storage tank at an elevation of 175 ft. Facilities for reclaiming practically all water not used for domestic purposes have been provided.

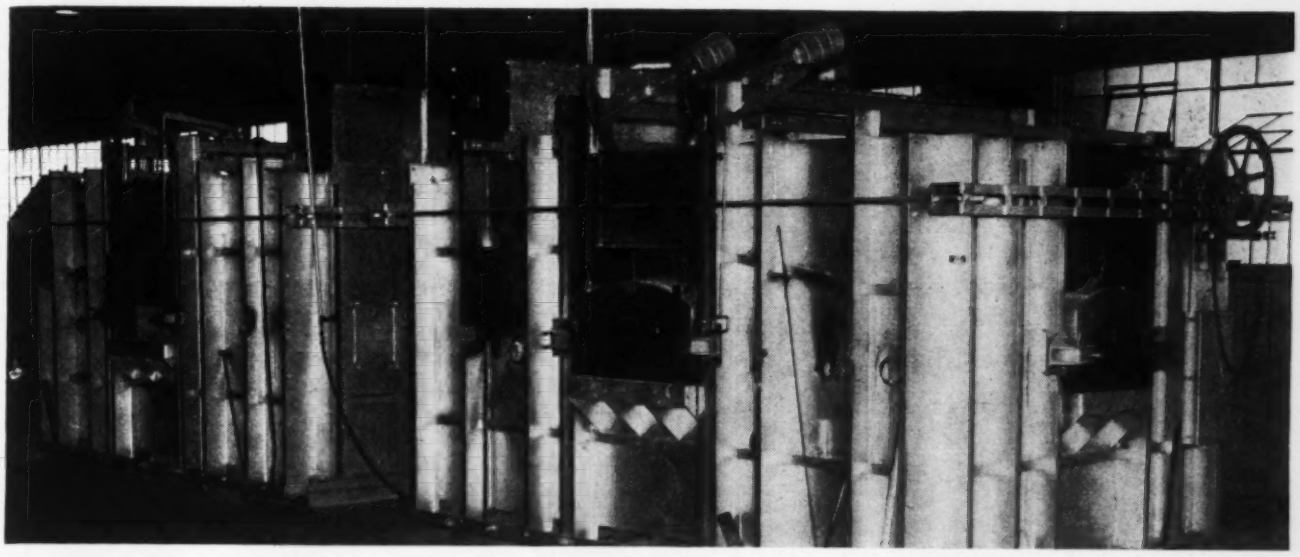
POWERHOUSE

In the powerhouse there are three boilers having a steaming capacity of 80,000 lb per hr each and one smaller unit of 30,000 lb capacity. The large boilers are equipped with combination oil and pulverized-fuel burners. The small boiler is a combination oil-fired unit and incinerator. Each is a bent-tube three-drum type, generating steam at 200 psi gage from water entering at 225 F. The boilers are completely water cooled with water walls and screen tubes running across the floor and up the side walls forming the furnace. Each boiler has automatic feedwater and combustion control. The ash is removed from the ash hopper by a steam vacuum system. The incinerator has a capacity of twenty tons per day of waste material, such as scrap paper, wooden crates, boxes, and the like. Electricity for plant use is not generated at the powerhouse which is designed to supply steam, compressed air, hot water, heat during the winter months, and refrigerated water for air conditioning during the summer months.

In the heating system, hot water from the boilers is piped to



SAND MOLDS ARE CARRIED INTO BAKING OVENS ON AUTOMATIC CONVEYERS SUSPENDED FROM OVERHEAD MONORAIL



IN THE FOUNDRY ARE "REMELT" FURNACES IN WHICH ALUMINUM SALVAGED FROM POURING AND CLEANING OPERATIONS IS RECLAIMED
("Scrap" aluminum enters the black door in the center of each furnace, is melted, and is poured out at the rear of the furnace into pig molds. The molds move on an automatic escalator type of conveyer which drops the pigs off when they are sufficiently hardened.)

overhead monitors or radiators backed by powerful fans which blow the heat horizontally out into the building. In the machine shop there are 56 monitors, each one capable of providing 30,000 cu ft of conditioned air per minute. In the assembly section, where the spray and wash units remove so much of the conditioned air through ventilator ports, there are 14 units with the capacity stepped up to 36,000 cu ft per min.

Electric power for the plant is purchased from The Cincinnati Gas and Electric Company and a master substation has been provided to step down the voltage of the incoming current. In addition to the master substation there are nine substations in the main plant, all located in the overhead structure, while in the foundry one such substation is provided. The master substation is divided into two units either capable of carrying the complete load for the factory.

SAND RECLAIMING DEVICE IN INTERIOR OF FOUNDRY
(The broken sand molds after "shakeout" are dropped into the trap in the foreground and the apparatus at the left rear returns the nails and wire for further sorting. The sand proceeds into the reclaimer on the outside of the building where the various steps in reclaiming are accomplished.)

CHIP SALVAGE

In the handling of surplus materials resulting from the various manufacturing operations, we have devised a method of chip handling for the Cincinnati plant to salvage all steel, aluminum, magnesium, copper, bronze, and other materials for reuse in national defense. At the same time approximately 98 per cent of the cutting oil from the chips will be recovered.

Automatic chip handling will be used throughout the entire plant to speed up the reclaiming of this metal. In the usual manner, the chips will be raked out into a chip bin along side each machine. The bins will be raised by lift trucks, since they are too large for the operator to handle. These lift trucks haul the chips to large hoppers mounted on trailer trucks outside the plant. From five to eight of these trailer trucks will make up a train. As each train is filled it will be hauled by tractor to the chip handling house. These chips will then be crushed to uniform size, dumped into a centrifuge, and as the chips are whirled at high speed, cutting oil is thrown off into the drain. Cleaned of the oil, the chips are then dumped into two bins of 100 tons capacity erected over a railroad siding. Semiautomatic load-control permits loading of a gondola car in eight minutes. A similar bin is located over a driveway for use in handling aluminum chips to be hauled away by trucks.

CAFETERIAS AND REST ROOMS UNDERGROUND

Cafeteria, lockers, and toilet facilities are all located underground. There are approximately a quarter of a million square feet of floor area provided in the basement in which these facilities are housed. Two cafeterias and three lunchrooms are provided for employees. These rooms are capable of seating 5000 persons at any one time. Locker rooms are easily accessible from the main floor of the plant and from the outside of the building. Waiting rooms have likewise been provided for the oncoming shift. The oncoming shift is not permitted in the

SAND MOLDS READY FOR POURING

(They are moved on the roller-type conveyer to the pouring shed where they receive the molten aluminum, then on the same conveyer to the cooling area and finally to the "shakeout.")

manufacturing area until seven minutes before starting time, therefore, it is essential that these waiting rooms be provided. Since the excavated area does not extend beneath the entire building, additional toilet facilities are necessary, and these likewise have been provided below ground level at convenient locations.

ENGINE TESTING

The test cells are interesting in that every engine, after final assembly, is mounted on a stand and subjected to a seven-hour production run. The test-cell air inlet and outlet stacks are lined with sound-absorbent material to reduce the noise incident to operating a 1700-horsepower engine with open exhaust stacks. The flow rates and consumption, pressures, and temperatures of fuel, oil, and carburetor air are accurately measured as are the speed and power. These are adjusted to pre-established limits by a complete complement of rotometers, tachometers, remote pressure and temperature gages, potentiometers, and other precision instruments on every test stand.

In the majority of test stands power is absorbed by a calibrated wooden four-bladed test propeller. Only four of the stands are equipped with power absorption dynamometers. With these, power readings may be measured directly at any operating speed. A percentage of production engines are completely calibrated on these dynamometers for power at various speeds. The data thus accumulated may later prove to be useful in the solution of specific engineering problems.

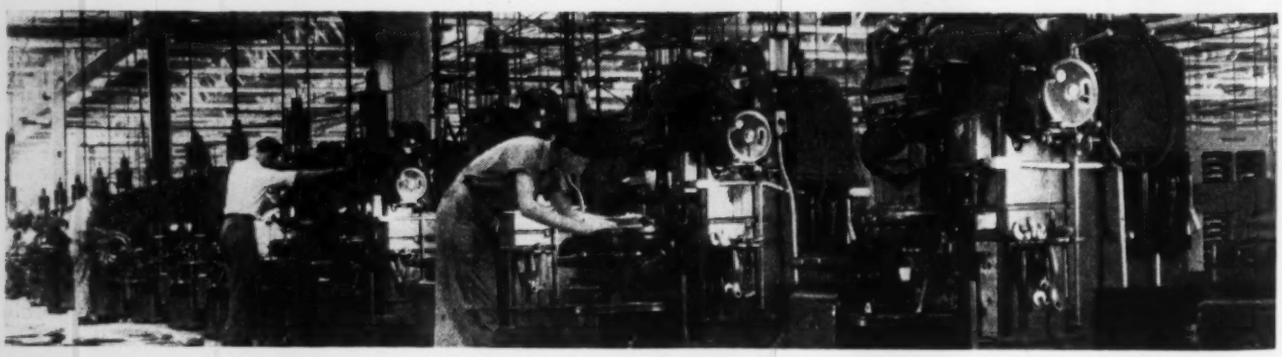
After the production run all engines are disassembled for inspection. If all parts are satisfactory, the engine is reassembled and subjected to a final test of approximately five hours' duration. It is gradually accelerated to its peak guaranteed speed and horsepower. This multiplicity of testing on all production engines accounts for the need of 72 test cells.

PLANT ORGANIZATION

The organization of the Cincinnati plant is somewhat similar to that of any other large organization, having divisions located in areas some distances removed from the home plant. The Cincinnati plant is headed by a manager, with department heads reporting directly to him. These various departments represent personnel, manufacturing, purchasing, engineering, plant engineering, inspection, accounting, and sales and service. All of these groups tie in functionally with the corresponding departments in the home office in Paterson.

In the case of the engineering department, only such engineering as is related to the manufacture of the product is carried on at the Cincinnati plant. All experimental and development work is handled from the Paterson area inasmuch as the facilities are already established there for that control. Similarly, the sales and service department handles only those activities relating to the manufacturing and shipping phases. All outside contact with the customer, both as related to customer liaison and service, is likewise carried on by the home office.

The plant is practically completed and both the foundry and manufacturing facilities have been in operation since April 14 of this year. The first engine was shipped on June 12, on which day the plant was dedicated to national defense. Although only a few engines were shipped that month, they represented the accomplishment of the purpose for which the plant was placed in the midwestern area. By the middle of 1942, an operating peak will be accomplished. Naturally, the peak in employment will be several months earlier and of the 12,000 employees mentioned early in this paper approximately 9000 will have been trained in the Cincinnati area. Of this entire group of employees, only 300 families were moved from the Paterson area. Most of this group were in a supervisory or executive capacity and on this nucleus has been built the present organization consisting of office workers, machine operators, and the many other classifications required for the manufacture of the Cyclone 14.



LINE OF FELLOWS GEAR SHAPERS MACHINING GEARS FOR A CYCLONE 14

(One operator is able to feed and operate three machines.)

HEAT-TREATMENT *of* MOLYBDENUM HIGH-SPEED STEELS[1]

IT SHOULD be borne in mind that where hardening equipment is available in which decarburization can be controlled, there is no particular problem involved in replacing the tungsten high-speed steel with the proper molybdenum high-speed steel. There are differences in hardening temperatures and timing cycles but the broad general principles are similar.

Where proper equipment does not exist, the special precautions indicated below should be helpful.

High-speed steel is defined by the O.P.M. as follows:

The term "high-speed steel" as herein used is defined as including two classes of alloy steels:

(1) "Class A high-speed steel" is hereby defined as either alloy steel containing not less than 0.60 per cent carbon and containing more than 3.0 per cent molybdenum; or alloy steel containing not less than 0.60 per cent carbon, containing 7.0 per cent or less tungsten, and containing more than 3.0 per cent molybdenum.

(2) "Class B high-speed steel" is hereby defined as alloy steel containing not less than 0.55 per cent carbon and containing more than 12.0 per cent tungsten.

NOTE: Other alloy materials may be present in the steels of either class, but steel not containing the substances named, in the amounts specified, shall not be considered high-speed steel.

The compositions for molybdenum high-speed steels as given in Table 1 include only those steels most widely used and established for general commercial tool applications. There are additional compositions which are used for special applications. Since they require special heat-treatment to handle properly, their use is not discussed in this practice.

TABLE 1 COMPOSITIONS FOR MOLYBDENUM HIGH-SPEED STEELS

	Type I Molybdenum-tungsten		Type II Molybdenum-vanadium	Type III Tungsten-molybdenum
	a	*b**		
C	0.70–0.85	0.76–0.82	0.70–0.90	0.75–0.90
W	1.25–2.00	1.60–2.30	.....	5.00–6.00
Cr	3.00–5.00	3.70–4.20	3.00–5.00	3.50–5.00
V	0.90–1.50	1.05–1.35	1.50–2.25	1.25–1.75
Mo	8.00–9.00	8.00–9.00	7.50–9.50	3.50–5.50
Co	See footnote	4.50–5.50	See footnote	See footnote

* Cobalt may be used in any of these steels in varying amounts up to 9.00 per cent and the vanadium may be as high as 2.25 per cent. When cobalt is used in Type III, this steel becomes susceptible to decarburization. As an illustration of the use of cobalt, Type 1*b* is included. This is steel T10 in the U. S. Navy Specification 46S37, dated Nov. 1, 1939.

For those who are not skilled in handling molybdenum high-speed steels and who do not have decarburization under good control, it is recommended that at present they adopt the following procedure:

(1) Use the required substitution of molybdenum high-speed steels, selecting the type that will produce the best results and give the least trouble in working. The smaller tools are heat-treated by shorter cycles and thus the general hazards are less.

(2) Proceed on the basis that steels of Type III decarburize less than steels of Type I or II. In most cases steels of Type III can be treated without surface protection in the same equipment used for tungsten high-speed steels.

(3) Consult with the firms from whom you purchase your high-speed steels for their best advice in the light of your particular problem.

(4) Take steps to obtain modern, efficient hardening equip-

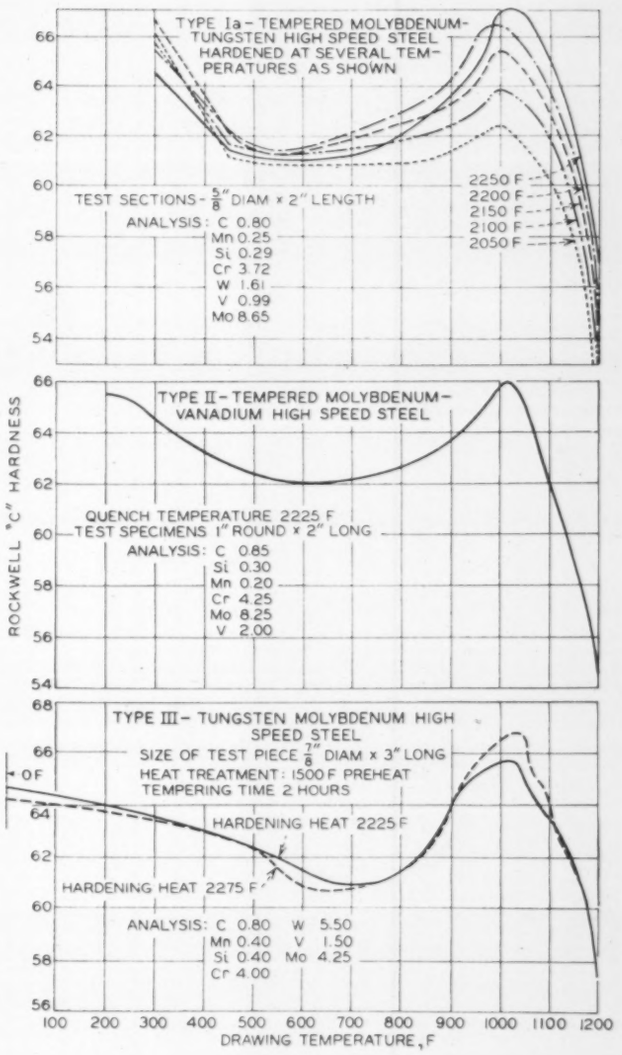

TYPE Ia – TEMPERED MOLYBDENUM-TUNGSTEN HIGH SPEED STEEL HARDENED AT SEVERAL TEMPERATURES AS SHOWN
TEST SECTIONS – 5/8" DIAM x 2" LENGTH
ANALYSIS: C 0.80 Mn 0.25 Si 0.29 Cr 3.72 W 1.61 V 0.99 Mo 8.65
2250 F
2200 F
2150 F
2100 F
2050 F
TYPE II – TEMPERED MOLYBDENUM-VANADIUM HIGH SPEED STEEL
QUENCH TEMPERATURE 2225 F
TEST SPECIMENS 1" ROUND x 2" LONG
ANALYSIS: C 0.85 Si 0.30 Mn 0.20 Cr 4.25 Mo 8.25 V 2.00
TYPE III – TUNGSTEN MOLYBDENUM HIGH SPEED STEEL
SIZE OF TEST PIECE 7/8" DIAM x 3" LONG
HEAT TREATMENT: 1500 F PREHEAT
TEMPERING TIME 2 HOURS
HARDENING HEAT 2225 F
HARDENING HEAT 2275 F
ANALYSIS: C 0.80 Mn 0.40 Si 0.40 Cr 4.00 W 5.50 V 1.50 Mo 4.25
ROCKWELL "C" HARDNESS
DRAWING TEMPERATURE, F

FIG. 1

[1] Prepared by a special committee of the Office of Production Management. The personnel of this committee is as follows: N. I. Stotz, *Chairman*, J. H. McCadie, W. H. Wills, F. Lloyd Woodside, and J. Edward Donnellan, *Secretary*.

ment on the premise that regardless of the kind of high-speed steel being hardened, proper hardening promotes better tool life and better tool life in itself is a big step in conservation.

FORGING

These steels can be forged like the tungsten type but at a slightly lower temperature, see Table 2. When heating the molybdenum high-speed steels for forging, they should be held in the furnace for the shortest time possible at the forging temperature.

TABLE 2 HEAT-TREATMENT OF MOLYBDENUM HIGH-SPEED STEELS[1]

	Type I Molybdenum-tungsten *a* and *b*	Type II Molybdenum-Vanadium	Type III Tungsten-Molybdenum
Forging	1850–2000 F	1850–2000 F	1900–2050 F
Not below	1600 F	1600 F	1600 F
Annealing	1450–1550 F	1450–1550 F	1450–1550 F
Strain relief	1150–1350 F	1150–1350 F	1150–1350 F
Preheating	1250–1500 F	1250–1500 F	1250–1550 F
Hardening[3]	2150–2250 F[2]	2150–2250 F	2175–2275 F
Salt	2150–2225 F	2150–2225 F	2150–2250 F
Tempering	950–1100 F	950–1100 F	950–1100 F

[1] Hardening curves of the various types are appended.
[2] Under similar conditions Type *b* requires a slightly higher hardening heat than Type *a*.
[3] The higher side of the hardening range should be used for the large sections and the lower side for the small sections.

Like all types of high-speed steel, large pieces should be preheated to 1000–1200 F before heating to the forging temperature.

Slightly oxidizing atmospheres are preferred when no protective coating is used. No protection is necessary for ordinary-sized forgings unless long heating cycles are involved. Borax is a very effective coating but has the disadvantage of making the surface of the steel very slippery at the forging temperature so the operator should take due precautions. To minimize the fluxing action on the furnace refractories, an excess of borax should be avoided.

After forging it is desirable to cool slowly to about 300 F to avoid cracking from forging strains. This can be accomplished by furnace cooling or burying in lime, mica, or dry ashes, or the like. Tools that have been forged should be machined or rough-ground, after annealing, to remove possible surface defects and to reduce the amount of grinding after hardening.

ANNEALING

Like tungsten high-speed steels, these steels should be annealed after forging and before hardening, or when rehardening is required. Box annealing is always preferable. When annealing partially finished tools, and generally when surface protection is of prime importance, it is recommended that cast-iron chips or other mild source of carbon be used for packing material.

Heat slowly and uniformly to the temperature given in Table 2, soak thoroughly, and then cool slowly in the furnace. The steel should not be taken from the furnace until it is below 1000 F.

After machining and before hardening it may be necessary to relieve harmful machining strains by annealing at 1150–1350 F.

HARDENING

The general method of hardening molybdenum high-speed steels resembles that followed with 18-4-1, but the hardening temperatures (Table 2) are lower and more precautions must be taken to avoid decarburization, especially on tools when made from Type I or II when the surface is not ground after hardening. Salt baths and atmosphere-controlled furnaces represent an excellent type of equipment for hardening molybdenum high-speed steel. The use of coke fires or the blacksmith forge is not recommended for hardening any high-speed steel, but if this type of equipment is all that is available, Type III may be so treated if an excess of air is avoided. However, simple surface protection in such equipment is safer practice even in the case of tungsten high-speed steels.

The usual method is to preheat uniformly in a separate furnace to 1250–1550 F and transfer to a high-heat furnace maintained at the hardening temperatures (see Table 2).

When heated in open fire or in furnaces without atmosphere control, these steels do not sweat like 18-4-1. Consequently, the proper time in the high-heat chamber is a matter of experience. This time approximates that used with 18-4-1 although slightly longer when the lower part of the hardening range is used. Much can be learned by hardening preliminary test pieces and checking up on the hardness fracture and structure. It is difficult to state exact heating time as this is affected by temperature, type of furnace, size and shape, and furnace atmosphere.

Rate of heat transfer is most rapid in salt baths, and slowest in controlled-atmosphere furnaces with high carbon-monoxide content.

QUENCHING

Quench the tool in oil, air, or molten bath. To reduce the possibility of breakage and undue distortion in intricately shaped tools, it is advisable to quench in a molten bath at approximately 1100 F. The tool may be quenched in oil and removed while still red or at approximately 1100 F. The tool is then cooled in air to room temperature and tempered immediately to avoid cracking.

STRAIGHTENING

When straightening is necessary, it should be done after quenching and before cooling to room temperature prior to tempering.

TEMPERING

Reheat slowly and uniformly to 950–1100 F. For general work 1050 F is most common. Hold at temperature at least one hour. Two hours is a better safe minimum and four hours is maximum. The time and temperature depend on the hardness and toughness required. Where tools are subjected to more or less shock, multiple temperings are suggested.

[Sections on salt baths and furnaces are covered in separate reports of O.P.M. Salt Bath Committee and O.P.M. Furnace Committee.—EDITOR.]

COATINGS

Borax may be applied by lightly sprinkling over the steel when heated to a low temperature (1200–1400 F). Small tools heated in the foregoing manner may be rolled in a box of borax. Another method more suitable for finished tools is to apply the borax or boric acid in the form of a supersaturated water solution. In such cases the tools are immersed in the solution at 180–212 F, or it may be applied with a brush or spray. Pieces so treated are heated as usual with care taken in the handling to insure good adherence.

Special protective coatings[2] or paints when properly applied have been found extremely useful. They do not fuse or run at

[2] The trade names of these products that are known at present are as follows: No-Carb, Park Chemical Co., 8074 Military Ave., Detroit, Mich.; Sel-Car, National Copper Paint Co., 110 S. Dearborn St., Chicago, Ill.; Ferritol, E. F. Houghton, 3rd, American & Somerset Sts., Philadelphia, Pa.

the temperatures used and therefore do not affect the furnace hearth. When applying these coatings, it is necessary to have a surface free from scale or grease to insure good adherence. They may be sprayed or brushed on and usually one thin coat is sufficient. Heavy coats tend to pit the surface of the tool and in addition cause difficulty in its subsequent removal. Tools covered with these coatings should be allowed to dry before charging into the preheat furnace. After hardening and tempering the coating can be easily removed by light blasting with sand or steel shot. When tools are lightly ground, these coatings come off immediately.

SPECIAL SUGGESTIONS

As in the case of tungsten high-speed steels, tools with sharp corners, variable cross sections, or very large sizes should not be given too drastic a quench in oil. It is better to remove the tool from the oil when cooled to or just below a red heat and allow it to cool in the air. Equalizing in lead or molten salt at about 1100 F and then cooling in still air is good practice.

Single-point cutting tools, in general, should be hardened at the upper end of the temperature range as given in Table 2. Slight grain coarsening on such tools is not objectionable when they are properly supported in service and not subjected to chattering.

However, when such tools are used for intermittent cut, it is better to use the middle of the temperature range. All other cutting tools such as drills, countersinks, taps, milling cutters, reamers, broaches, and form tools should be hardened in the middle of the range.

Certain applications requiring a maximum toughness (to resist shocks) will require the lower end of the hardening range. Examples are slender taps, cold punches, blanking and trimming dies.

The molybdenum high-speed steels may be pack-hardened following the same practice as used with tungsten high-speed steels but keeping on the lower side of the hardening range (approximately 1850 F).

Molybdenum high-speed steels will take all the special surface treatments, including nitriding by immersion in molten cyanide, that are applied to tungsten high-speed steels for certain applications.

When borax and boric acid are used in a furnace with a silicon-carbide bottom, it is necessary to use a metal pan preferably of stainless iron to prevent the borax from fusing with the silicon carbide. Such fusion produces a glass-like insoluble coating on the tool which is impossible to remove without damage to the cutting edge.

Salt-Bath Method for Hardening Molybdenum High-Speed Steels[3]

ONE of the contributing factors in the use and adoption of the molybdenum types of high-speed steels as a substitute for the 18-4-1 has been the electric salt-bath method for hardening.

Because molybdenum high-speed steels decarburize when heated, the conventional type furnaces are not satisfactory for hardening. The electric salt-bath method when properly controlled eliminates this decarburization and is satisfactory for all types of molybdenum high-speed steels.

SALT-BATH FURNACES

In general, immersed-electrode furnaces are being used where there is sufficient production to keep furnaces operating at a reasonable capacity. There are on the market today several types of immersed-electrode salt-bath furnaces and several types of salt baths. As a guide to those who are considering purchasing or installing such equipment, it is recommended that the selection of this equipment be made to suit their own production requirements from the equipment recommended.

The immersed electrodes generate heat directly in the molten salt bath itself by the electrical resistance of the bath material, and produce a positive circulation of the bath, due to the internal stirring action caused by the electrical flow between the electrodes. This stirring action increases the speed of heating and eliminates local overheating thus aiding close temperature control which is always advantageous. A properly selected and maintained salt bath prevents scaling or oxidation of the work, and also when properly controlled prevents surface decarburization.

The following equipment is recommended:

For Heavy Production and Constant Use: A three-pot unit consisting of:

(*a*) Immersed-electrode salt-bath preheat furnace.
(*b*) Immersed-electrode salt-bath high-heat furnace.
(*c*) Immersed-electrode salt-bath quench furnace.
(*d*) Optional: For extremely heavy production or large or intricate sections, two preheats are advantageous; the first to be operated at 1100–1300 F, and the second one at 1500–1600 F.

For Medium or Light Production, but Used Intermittently: A three-pot unit consisting of:

(*a*) Gas- or oil-heated salt-bath preheat furnace.
(*b*) Immersed-electrode salt-bath high-heat furnace.
(*c*) Gas- or oil-heated salt-bath quench furnace.

SALT BATHS FOR HARDENING

The manufacturers of salt baths (listed at end of this report) offer complete information on the method of use, as well as the method of chemical control, so that tools may be hardened free from any pitting or decarburization.

Decarburization or pitting in the high-heat salt bath is usually caused by the presence of oxides. However, the manufacturers of salt baths supply a neutral bath containing a suitable deoxidizer or rectifier for the bath, which is sufficient to keep the bath free from oxides under normal operating conditions.

Under abnormal operating conditions where a sufficient amount of new salt has not been added, it becomes necessary to make supplementary additions of rectifier material supplied by the manufacturer. These manufacturers will supply information as to procedure for simple chemical control to maintain the salt bath in a suitable condition.

When a refractory or brick-lined pot is used there is less tendency for formation of oxides in the bath.

PROCEDURE FOR SALT-BATH HARDENING

For recommended temperatures for hardening in the salt baths refer to the O.P.M. Committee Report for the Heat-Treat-

[3] Prepared by a special committee of the Office of Production Management. The personnel of this committee is as follows: A. F. Holden, *Chairman*, James McElgin, J. N. Bourg, W. J. Levy, and J. Edward Donnellan, *Secretary*.

ment of Molybdenum High-Speed Steels. Briefly, the procedure is as follows:

A Clean work free from scale, rust, oil, grease, and moisture. Use either solvent degreaser or suitable alkaline cleaner, followed by a clean hot-water rinse, and thorough drying. Every precaution must be taken to prevent moisture on tools going into the salt, as wet tools may cause a steam explosion, burning the operator.

B Immerse in preheat salt bath, temperature 1500–1550 F. Allow sufficient time for work to reach temperature of bath.

C Transfer to high-heat salt bath, temperature 2150–2250 F. Allow sufficient time for work to reach temperature of bath, plus proper soaking time at temperature. (See the heat-treating practice by the O.P.M. Committee on the Heat-Treatment of Molybdenum High-Speed Steels.)

D Transfer to quench bath, temperature 1100–1200 F. Allow sufficient time to cool to bath temperature. Two to five minutes will suffice, depending upon size. Remove from salt bath and cool in air or oil. Quenching in oil is not recommended for work of intricate design or work where distortion is apt to occur.

E After work has cooled to *room temperature*, wash off all adhering salts in a hot alkaline cleaner. If the work is to be tempered in a furnace (air atmosphere), the work should be shot- or sand-blasted or cleaned by other methods, to insure removal of all adhering salts. If this is not done, the salt will attack the work during the tempering. If a salt bath is used for tempering, the work need only be cleaned in a hot alkaline solution or hot water.

F For tempering, see the practice by the O.P.M. Committee on the Heat-Treatment of Molybdenum High-Speed Steels.

EFFECT ON SALT-BATH HARDENING

A The molybdenum high-speed steels when hardened in salt baths are entirely surrounded by neutral molten salt. A salt film is retained on the tool throughout the hardening procedure, thus preventing decarburization or scaling.

B The salt-bath hardening method provides uniform heating, and this generally results in less distortion. All sections of intricately shaped tools are uniformly heated by this method. The salt bath permits selective hardening.

C When a salt bath is properly selected and properly maintained, there is no chemical attack by this bath on the molybdenum high-speed steels. The original surface of the steel is retained.

Molybdenum high-speed steels will take all the special surface treatments, including nitriding when immersed in molten cyanide, that are applied to tungsten high-speed steels for certain applications.

There are many installations of salt-bath furnaces now in use for hardening molybdenum high-speed steels. The manufacturers of salts and salt-bath furnaces listed below are qualified by experience to give complete engineering service:

Electrode Salt-Bath Furnace Manufacturers: Ajax Electric Company, Philadelphia, Pa.; Bellis Heat Treating Company, Branford, Conn.; Commerce Pattern Foundry & Machine Co., Detroit, Mich.; The A. F. Holden Company, New Haven, Conn.

High-Speed Salt-Bath Manufacturers: Bellis Heat Treating Company, Branford, Conn.; The A. F. Holden Company, New Haven, Conn.; The E. F. Houghton Company, Philadelphia, Pa.; Park Chemical Company, Detroit, Mich.

Gas- or Oil-Fired Pot Furnaces: Any furnace manufacturer producing pot furnaces of which there are approximately 25.

Controlled-Atmosphere Furnaces for the Heat-Treatment of Molybdenum High-Speed Steels[4]

MOLYBDENUM high-speed steels have a tendency to develop a soft surface when heated to the hardening temperatures. Because of this tendency it is necessary and important to exercise certain well-established precautions to protect the surface of these steels.

In addition to the application of protective coatings when conventional type furnaces are used, and also the use of high-temperature salt baths, atmosphere-controlled furnaces satisfy this demand for surface protection against attack. These furnaces are now available in both electric and fuel-fired types where the atmosphere is independent of the source of heat. This permits control of the atmosphere in contact with the work to be treated. Small and delicate pieces can be given the heat-treatment that will develop the good properties of the steel without injuring the surface or overheating thin projections.

The ideal atmosphere is one that is not harmful to the steel. The atmospheres commonly used are products of combustion and inert gases both of which have been cleaned of undesirable constituents and closely regulated as to composition.

The manufacturers of atmosphere-controlled furnaces that are in general use for the hardening of molybdenum high-speed steels are listed in this report. In each case, it is claimed by the manufacturer that these furnaces, when properly operated, have proved satisfactory in eliminating decarburization or other harmful attacks in the heat-treatment of molybdenum high-speed steels.

[4] Prepared by a special committee of the O.P.M. The personnel of this committee is as follows: C. I. Hayes, *Chairman*, P. B. Crocker, W. M. Hepburn, Norbert Koebel, Karl Ness, and J. Edward Donnellan, *Secretary*.

CHARACTERISTICS OF ATMOSPHERES CAPABLE OF PROTECTING MOLYBDENUM HIGH-SPEED STEELS

An atmosphere for the successful heat-treatment of molybdenum high-speed steels must be: (1) Capable of preventing decarburization; (2) capable of preventing excessive carburization which will cause wrinkling of the surface, melting of the edges, pitting, and embrittlement of the cutting edge; and (3) capable of preventing harmful scale or oxidation.

Preheat Temperatures. To prevent the foregoing changes from taking place, the atmosphere for the preheat temperature is just as important as the atmosphere for the high-heat temperature. The atmosphere for the preheat temperature should have the same characteristics as the atmosphere for the high-heat temperature. A high-heat furnace equipped with an atmosphere for satisfactory hardening will be of no value if the proper atmosphere is not used on the preheat furnace.

High-Heat Temperatures. As any one of several atmosphere-control methods may be used, no general recommendations can be made regarding settings and methods of operation, but competent engineering service should be supplied by the furnace manufacturers. Complete operating information should always be given by the service engineers after the furnaces are installed.

(Continued on page 718)

Modern TIMBER-CONSTRUCTION METHODS *in* EUROPE

By E. GEORGE STERN

VIRGINIA POLYTECHNIC INSTITUTE, BLACKSBURG, VA.

DURING the last few years several surveys of the present status of timber research and timber construction in America have been published in various magazines (1, 2, 3, 4).[1] The purpose of this paper is to give information on some of the research and design practices in timber construction made available during the last few years in European countries. It will be noted that many of the ideas were conceived in time of economic warfare during which the desire of some countries for self-sufficiency required the architect and engineer to find new methods of construction or else cease building. These methods make it possible to substitute lumbers of small sizes and dimensions, which can be obtained almost everywhere without delay, for steel, reinforced concrete, or large-size timbers. Often the construction results in substantial savings in material, although sometimes an increase in cost of labor is thereby necessitated. It is up to the architect and engineer to determine whether this possible increase in labor will permit the introduction in this country of any of the design practices to be described.

G-BEAM, BUILT-UP WOODEN BEAM WITH STEEL REINFORCEMENT

The G-beam or Goldes beam (named for carpenter Anton Goldes of Munich) consists of three boards, a flat-rolled steel strap, two hardwood fillers, and four hardwood dowels, Fig. 1. The three boards and the flat steel strap, which is stressed by the parabolically curved or triangularly cut center board, carry the load. The curved board increases the load-carrying capacity of the beam, as compared with the triangular board, because of the better stress distribution. The beam is built up by means of cold or synthetic-resin glue and nails which fulfill the purpose of reinforcement of the glue connections and that of a press simultaneously.

The manufacture of the G-beam does not require special equipment. The beam can be built by any skilled carpenter in his shop. In order to calculate the proper dimensions for the wooden boards and the flat steel, consideration has to be given to the fact that steel and lumber should deflect an equal amount, that is, $d_s = d_l = d$. Furthermore, the total load should be distributed uniformly to the steel and lumber, hence, $P_s + P_l = P$.

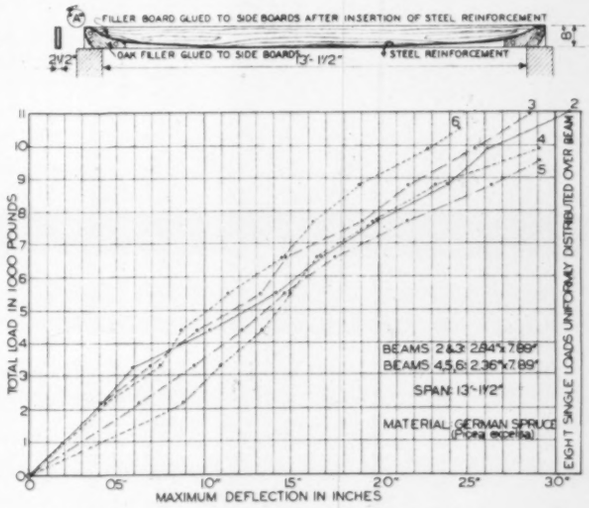
The G-beam was found to be stronger than the simple beam because the flat steel strap can take care of approximately 50 per cent of the bending moment, according to tests on three simple beams and three G-beams (24). For $2^1/_2 \times 8$-in. beams of 13-ft span, the following test loads were recorded before horizontal-shear failures occurred:

Test no.	Maximum test load, lb — Simple beams	G-beams
1	3960	11660
2	6000	11880
3	8470	12210

The tests indicate that the maximum loads for simple beams vary up to 115 per cent, while those for G-beams vary only approximately 4 per cent. The use of three different boards glued together to form one single beam causes a better stress distribution than in a simple (not laminated) beam, while the use of a steel strap accounts for a reduction in the tensile stresses of the bent lumber.

Static bending tests indicate that the built-up beams react under load in a manner similar to the simple beams in regard to their deflections. However, the lack of data from dynamic tests calls for discretion when dynamic loads are applied. Also, the influence of changes of temperature on the strength characteristics of the beams has not been investigated.

Compared with simple wooden beams of the same load-carrying capacity, the saving of lumber amounts to 60 per cent while a comparatively small amount of steel is needed for the construction. The additional labor per square foot of floor construction compared to that with simple wooden beams is 0.011 hr. Boards for this type of construction can be more easily obtained than timbers of large size and because of the decreased amount of essential materials, transportation cost is reduced.


FILLER BOARD GLUED TO SIDE BOARDS AFTER INSERTION OF STEEL REINFORCEMENT
OAK FILLER GLUED TO SIDE BOARDS
STEEL REINFORCEMENT
2 1/2"
13'-11 1/2"
TOTAL LOAD IN 1000 POUNDS
MAXIMUM DEFLECTION IN INCHES
EIGHT SINGLE LOADS UNIFORMLY DISTRIBUTED OVER BEAM
BEAMS 2&3 2.84"x7.89"
BEAMS 4,5,6 2.36"x7.89"
SPAN 13'-11 1/2"
MATERIAL GERMAN SPRUCE

LOAD-DEFLECTION CURVES FOR BUILT-UP WOODEN BEAMS WITH STEEL REINFORCEMENT (G-BEAMS)

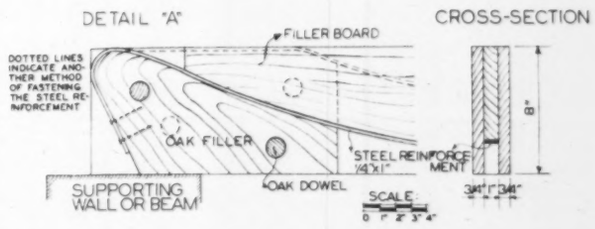
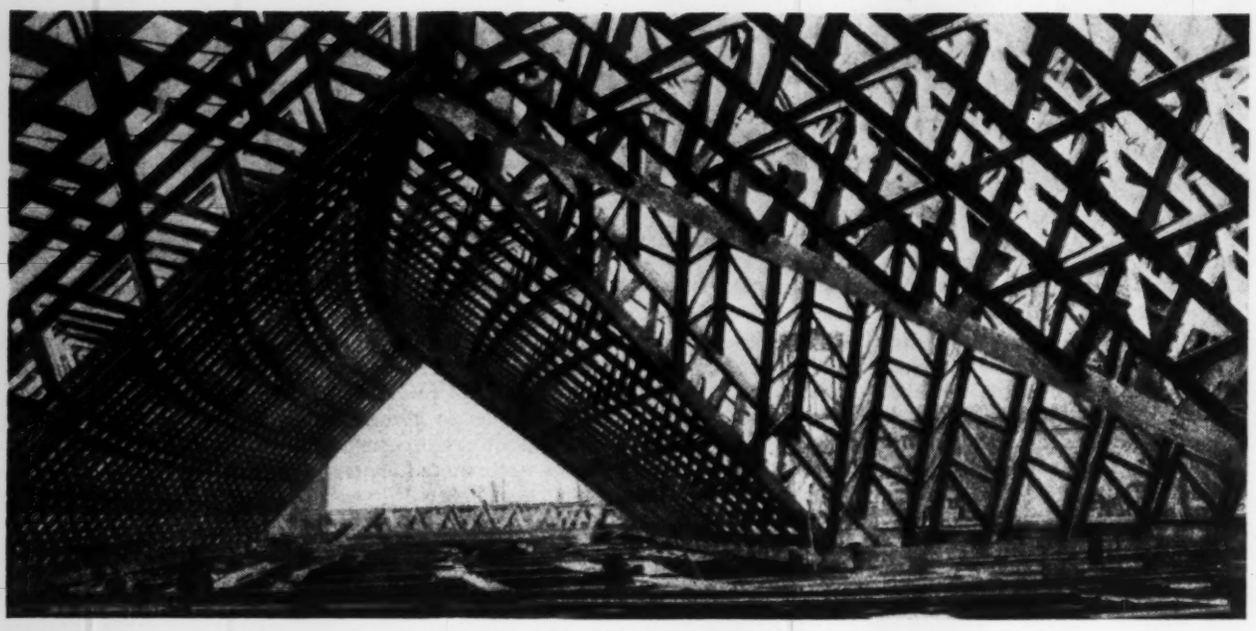


FIG. 1 G-BEAM, A BUILT-UP WOODEN BEAM WITH STEEL REINFORCEMENT

[1] Numbers in parentheses refer to the Bibliography.

Contributed by the Wood Industries Division, for presentation at the Fall Meeting, Louisville, Ky., October 12–15, 1941, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.



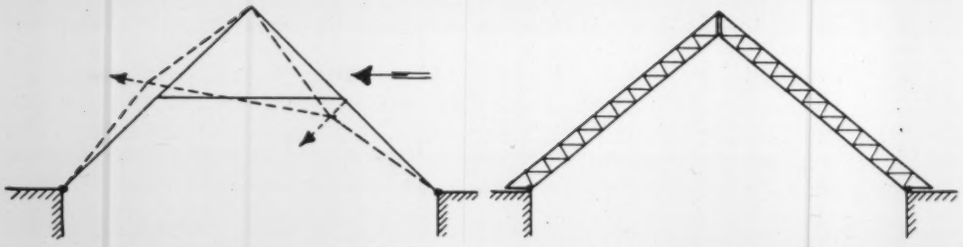
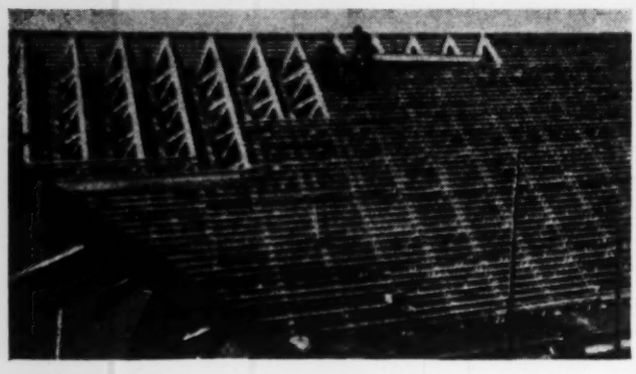
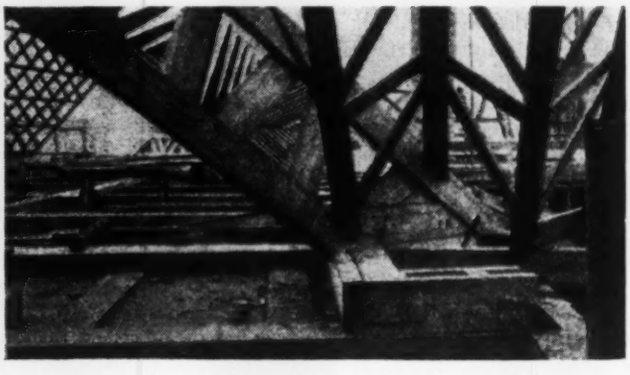


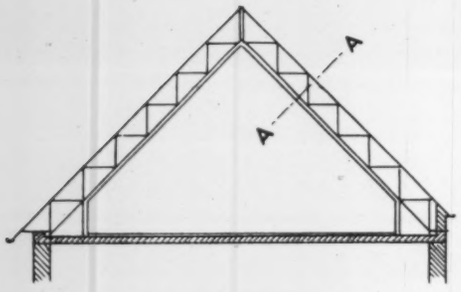
FIG. 2 THE LUDWIG KROHER TIMBER ROOF CONSTRUCTION
(At top is shown the L.K. construction applied in Munich, Germany, in 1938. Sketch shows a commonly used roof construction at the left replaced by L.K. construction.)



(*a*)

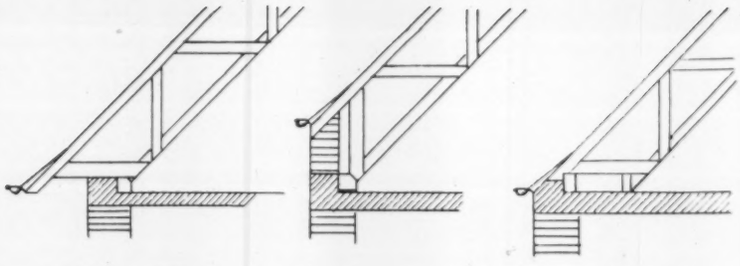


(*b*)



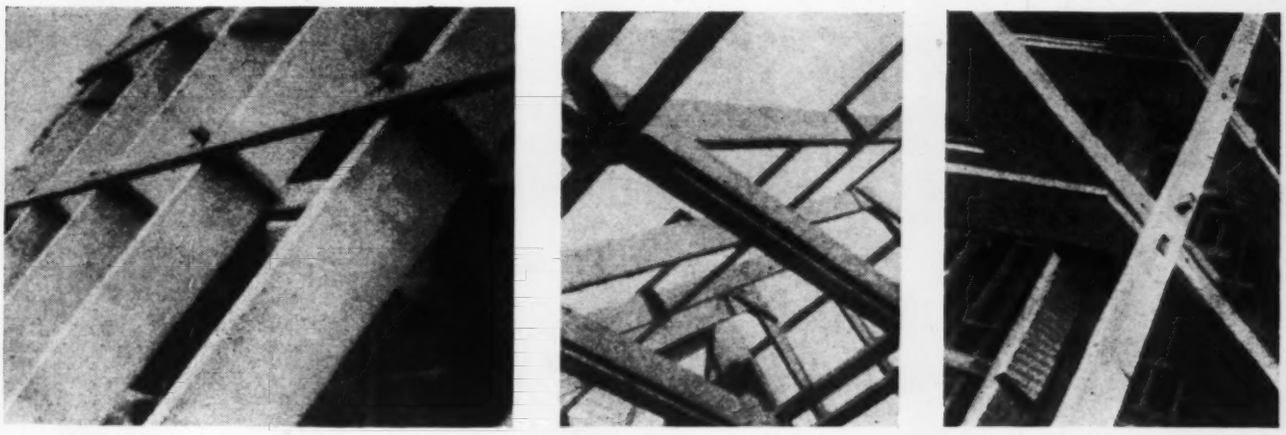
SECTION: A-A

SCHEMATIC SECTION THROUGH A L K. TIMBER ROOF STRUCTURE INDICATING THE UNOBSTRUCTED AND WELL INSULATED SPACE UNDER THE ROOF

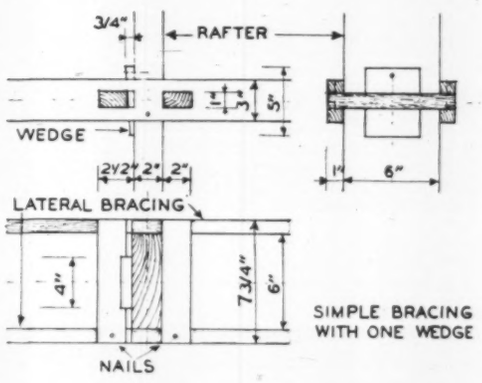


THREE TYPES OF HEEL CONNECTIONS FOR THE L. K. TIMBER ROOF TRUSS

FIG. 3 LUDWIG KROHER TIMBER ROOF CONSTRUCTION DETAILS
(*a* Roofers firmly nailed to trussed rafters secure a stiff longitudinal bracing of the numerous trusses. *b* Lower joint of L.K. roof trusses.)



(a) (b) (c)



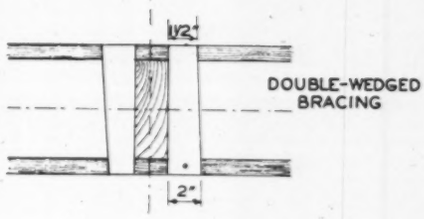


FIG. 5 THE VOLLMAR ROOF-TRUSS CONSTRUCTION
(*a* Laterally braced rafters; double-wedged. *b* View to ridge of roof. *c* Splicing of double-wedged lateral bracing.)

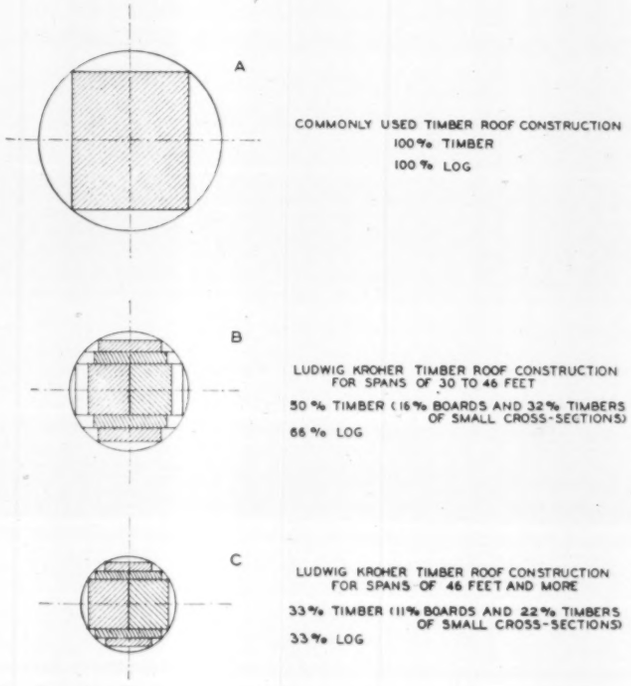

A
COMMONLY USED TIMBER ROOF CONSTRUCTION
100% TIMBER
100% LOG
B
LUDWIG KROHER TIMBER ROOF CONSTRUCTION FOR SPANS OF 30 TO 46 FEET
50% TIMBER (16% BOARDS AND 32% TIMBERS OF SMALL CROSS-SECTIONS)
66% LOG
C
LUDWIG KROHER TIMBER ROOF CONSTRUCTION FOR SPANS OF 46 FEET AND MORE
33⅓% TIMBER (11% BOARDS AND 22% TIMBERS OF SMALL CROSS-SECTIONS)
33⅓% LOG
EFFICIENCY OF CONSTRUCTIONS A:B:C = 1:4:6

FIG. 4 EFFICIENCY DIAGRAM AS REGARDS USE OF LUMBER WITH LUDWIG KROHER TIMBER ROOF CONSTRUCTION
(Relative timber and log sizes required for various types of timber roof construction.)

LUDWIG KROHER TIMBER ROOF CONSTRUCTION ACCOMPLISHES 40 to 70 PER CENT TIMBER SAVING

The Ludwig Kroher (L.K.) timber roof construction consists of a series of stiffly trussed, continuously connected girders which are built in two planes in the direction of the slope of the roof supporting each other and sloping against each other, accordion-like. These girders, Fig. 2, run directly below the roof covering and sheathing, and permit the space under the roof to be completely unobstructed by trusses, columns, purlins, and braces. The trussed girders consist of rafters which are located in two parallel planes, and compression and tension members as indicated in Fig. 3.

The L.K. timber roof construction may be economical for buildings more than 30 ft deep, particularly for large-size projects, barns, storage plants, mills, etc. It may be of advantage that a crane, installed directly under the ridge of the roof, can be moved along the entire length of the building, thus permitting economical use to be made of the total space under the roof.

According to the inventor of this type of construction, Ludwig Kroher of Munich, twelve major advantages of this construction (20) can be listed:

1 The construction is a continuous, stiff, three-hinged girder system.

2 It is statically determined because of its three-dimensional arrangement of triangles.

3 The loads are uniformly distributed over the supporting walls or wall framing and make large columns and piers unnecessary.

4 A separate longitudinal-girder system for bracing purposes can be omitted, because of the bracing within the girder construction.

5 The trussed girders are free of bent beams, as only compression and tension members exist.

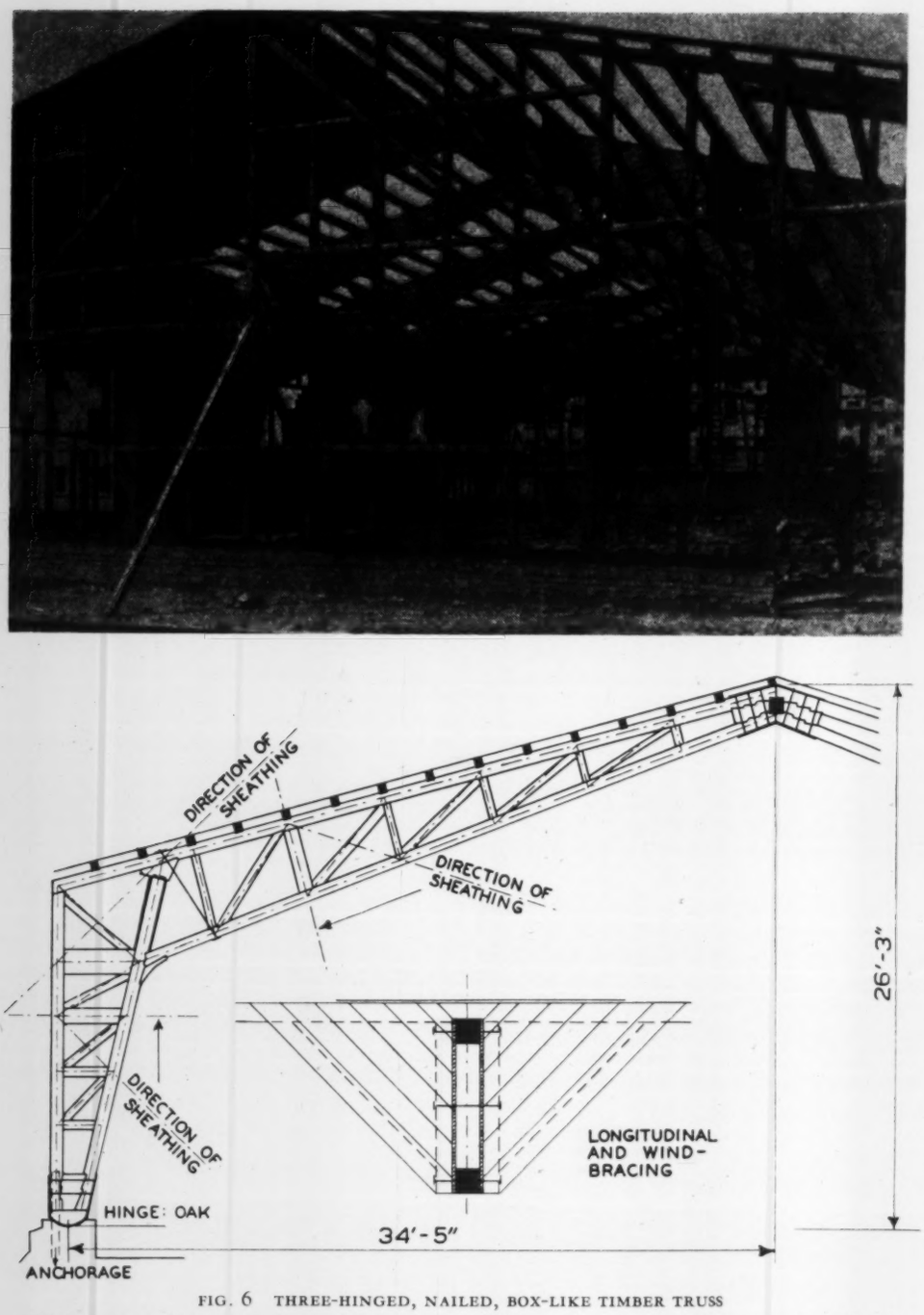


FIG. 6 THREE-HINGED, NAILED, BOX-LIKE TIMBER TRUSS

(Timbers stressed in compression, and sheathing stressed in tension. At top is shown an assembly of three-hinged trusses by W. Stoy of Hildesheim, Germany.)

6 The nonhomogeneity of structural lumber does not influence the strength of the continuous roof construction because of the numerous braces which stiffen the girder system.

7 A saving of 40 to 70 per cent of lumber can be made, as compared with types of construction commonly employed.

8 The use of small lumber cross sections is encouraged, and a better utilization of the smaller trees is guaranteed, Fig. 4.

9 Rapid erection of the structure, with a maximum of labor in the shop is made possible.

10 Nailed connections can be designed and used according to standard patterns.

11 A well-insulated roof can be obtained by the use of an inside sheathing or paneling.

12 The space under the roof is unobstructed by construction members.

VOLLMAR ROOF-TRUSS CONSTRUCTION SAVES 43 PER CENT IN TIMBER

By means of the lateral bracing of rafters and truss members with a single or double system of wedges, H. Vollmar of Cologne made it possible to save up to 43 per cent of timber in the construction of roof trusses (23). Furthermore, he simplified to a certain extent the erection of the roof construction by eliminating the use of heavy timbers which were replaced by thin boards nailed together at the joints and laterally braced to prevent buckling. Thus, the rafters of the roof and the compression and tension members of the trusses are laterally braced by two 1 × 3-in. wooden strips which in the case of rafters may also serve as roofers.

Two systems of bracing were designed: (*a*) double-wedged bracing with two wooden strips as wedges; (*b*), simple bracing with one lateral wooden-plate wedge, Fig. 5. The wedges are tacked to the rafters or bracing strips to prevent them from loosening during the erection of the structure. They can be driven tighter at any later date (before possible plastering) in order to make adjustments for possible shrinkage of the timber. Finally, the wedges are nailed firmly to the boards to prevent them from becoming misplaced.

The erection of the Vollmar roof truss is similar to that of any other timber structure. After the rafter boards have been nailed together, the trusses erected and temporarily braced, the bracing strips are nailed to the edges of the boards at their designated positions, and firmly wedged at every crossing of board and bracing strip.

A THREE-HINGED, NAILED, BOX-LIKE TIMBER TRUSS

The three-hinged, nailed, box-like timber trusses for a riding academy at Bernburg, Germany, were designed by W. Stoy, Hildesheim, according to a principle which makes it possible for the timbers to be stressed in compression while the sheathing is stressed in tension, Fig. 6.

The trusses of a span of almost 70 ft are built of timbers having a maximum cross section of 8 × 8 in. Each truss is assembled by means of 927 sq ft of 1-in.-thick sheathing, 110 lb of nails, and a comparatively small amount of hardware (35).

THE TOOTHED-RIBBON CONNECTOR

In order to save labor and to simplify and increase the efficiency of the nailed timber connection, a toothed-ribbon connector was designed and manufactured by W. Pfrommer, Karlsruhe. The toothed ribbon somewhat less than $^1/_{16}$ in. deep is manufactured in a width of $3^1/_2$ in. and in lengths of multiples of $3^1/_2$ in., with 35 in. as the maximum. Eighteen teeth are distributed over both faces of each $3^1/_2$-in. section, Fig. 7 (1, 19).

Each tooth is stamped out of the ribbon and is pressed into a curved shape in order to strengthen it against failure in bending. The teeth are uniformly distributed at the joints over the contact areas of the adjoining timber members. Hence, they make it possible to transmit relatively large forces over small timber areas. A single section of $3^1/_2 \times 3^1/_2$ in. can transmit 135 psi at any angle with the grain, according to static and dynamic tests (19). Both dowels and nails or bolts, which are used for securing the timbers in their position, transmit the load simultaneously. Hence, the loads can be distributed over dowels, nails, and bolts, and calculated accordingly.

The small teeth of the connectors are driven into the timbers, whence they are forced together by nails on about 1-in. spacing (for small lumber sizes) or by steel bolts on about $10^1/_2$-in. spacing (for larger timber sizes).

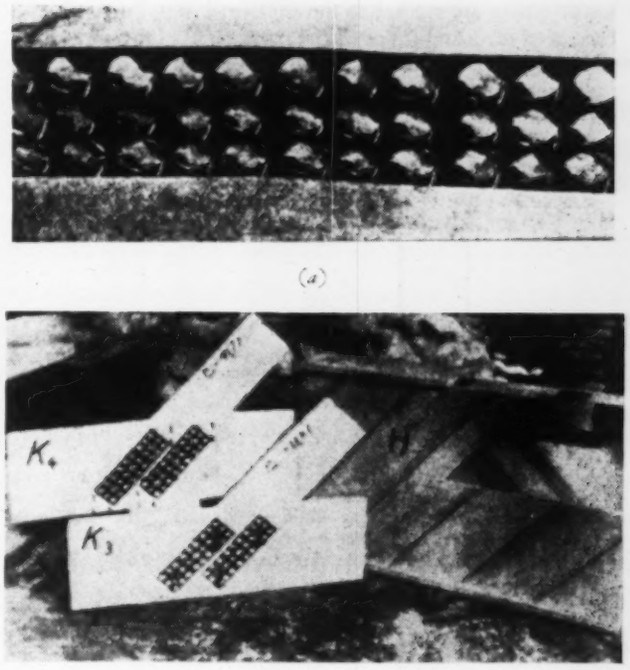
THE HARTL RING CONNECTOR

Ring connectors are used for joints of timber structures in order to build flexible connections with large load-carrying capacities. The use of the Hartl ring connector (43) fully meets the requirements of a statically determined method of construction, and thus makes possible correct static calculations of timber structures, even if dynamic or impact loads are applied (bridges, scaffolding, etc.). Secondary stresses in joints and members of the structures are eliminated, in contrast to the joints with steel gusset plates of steel structures, or joints of timber structures, fabricated by means of glue, nails, bolts, or plate and ring connectors.

The Hartl ring connector is designed with teeth distributed over one quarter of the circumference which penetrate into the lumber beyond the bottom of the ring groove. Hence the sharp shearing edge of the customary ring is eliminated. The shear area located deeper in the wooden member than in the case of other connectors is effective as far as the end of the piece, Fig. 8. The toothed ring is placed into precut grooves, as called for by the respective stresses in the members. The teeth are pressed into the fibers of the timber without cutting them severely. As the shearing area of the timber runs along the edge of the teeth, the claw-like effect of the teeth considerably increases the load-carrying capacity of the ring. Because of the fact that the teeth of the rings, in joints with members inclined rather than parallel to each other, can be placed in such a way that the timbers are stressed at an angle in the direction of the grain, the angle of the timber members is of no significance as to the load-carrying capacity of the rings. The main part of the load is transmitted from member to member along the toothed part of the ring, hence over the side of the member which is least subject to failure, Fig. 8.

Compression tests performed in the laboratories of the Technical University of Vienna on joints with average-grade spruce (*picea excelsa*) of a moisture content of 18.5 and 21 per cent of the dry weight, and a mean compressive strength parallel to the grain of 4750 and 4130 psi, respectively, and perpendicular to the grain of 380 and 410 psi, respectively, indicated a load-carrying capacity of 99,000 lb for a timber joint with one pair of rings of the size tested.

Because of the fact that the members of a joint with Hartl ring connectors can turn around the axis of the rings, this type of construction is particularly adapted to structures, the mem-



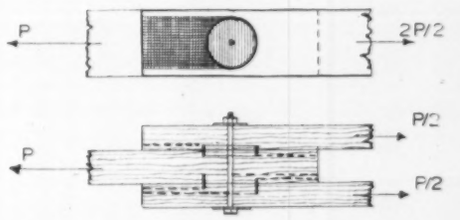
(a)

(b)

FIG. 7 THE TOOTHED-RIBBON CONNECTOR

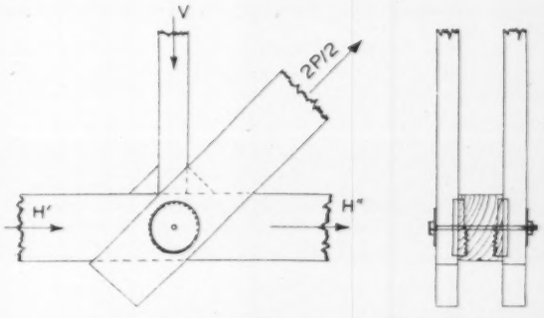
(*a* Continuous series of $3^1/_2$-in. units. *b* Built-up box girder with toothed-ribbon connectors.)

SINGLE RING FOR JOINTS WITH TWO-RING CONNECTORS
RING FOR GENERAL CONSTRUCTION PURPOSES
TWO-RING CONNECTOR FOR DYNAMICALLY LOADED STRUCTURES



CUSTOMARY RING CONNECTOR (UPPER RING IN CROSS-SECTION) AND TOOTHED HARTL RING CONNECTOR (LOWER RING IN CROSS-SECTION) IN A LUMBER JOINT

THE EFFECTIVE SHEARING FOR BOTH TYPES OF RING CONNECTORS



THE TWO-RING CONNECTOR IN JOINT WITH INCLINED STRUCTURAL MEMBERS

FIG. 8 THE HARTL RING CONNECTOR

bers of which are subject to movement in the joints caused by changes of form and shape of the structures (highway and railroad bridges, piers, anchorages of timber structures, etc.). The single ring might turn or shear off the core. The two-ring Hartl connector permits the motion to take place in the joint between the rings, which are pressed into the compression areas of the timbers. Metal moves along metal and thus allows freedom for adjustments.

For the construction of weather-exposed timber structures waterproofing plates are used between the contact areas of the timbers. Consequently, water cannot penetrate to the ring grooves, and rotting of timber is prevented at the drilled and grooved joints. As the straight members are virtually unaffected by unfavorable weather, the entire structure can be considered permanent.

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MODERN STEAM LOCOMOTIVE IN FREIGHT SERVICE

By C. E. POND

ASSISTANT TO SUPERINTENDENT OF MOTIVE POWER, NORFOLK AND WESTERN RAILWAY, ROANOKE, VA.

THE location of the Norfolk and Western and the principal points served by it are shown in the map, Fig. 1. The road extends from Norfolk, Va., on the east across the Blue Ridge and Allegheny mountain ranges to Columbus and Cincinnati, Ohio, on the west. From Hagerstown, Md., on the north to Winston-Salem and Durham, N. C., on the South. The Norfolk and Western is a heavy trunk-line railroad and the transporting of coal is the principal source of revenue. During the year 1940 it handled 45,000,000 net tons of revenue coal. Of this amount 33 per cent was handled east to the tidewater and 67 per cent was handled west to Columbus and Cincinnati, Ohio.

It may be thought that we have an ideal operating condition, for the coal originates in the mountains about midway between Norfolk and Columbus, and the road may be pictured as having a gradually descending grade in both directions. Such is not the case, as will be seen by referring to a condensed profile of the Norfolk and Western Railway between Norfolk, Virginia, and Columbus, Ohio, Fig. 2. The eastbound traffic must be lifted a total of 2574 ft over three mountain ranges, including four grades requiring pusher service. Main-line curvature as sharp as 12 deg and grades as heavy as 2 per cent are encountered. This demand for power rather than speed has a marked influence on the locomotive design.

In comparing the development of the modern freight locomotive, the year 1925 will be compared with 1940. I take those two years purposely because the gross earnings were almost identical—$105,200,000—and the comparisons will indicate the improvements in locomotives and the manner in which we use them. Table 1 is a comparison of the more important data pertaining to the improvement in operating efficiency which has taken place in the last 15 years. In 1925 we handled a business of 27 billion tons with 653 road locomotives while in 1940 we handled a slightly larger business—30 billion tons—with only 347 road locomotives. In 1925 gross ton-miles per train-hour—the best measure we have of operating economy—was 32,212, and in 1940 it increased to 57,984, an increase of 80 per cent.

During this period a substantial improvement was made in the pounds of coal consumed per 1000 gross ton-miles. It decreased from 147 in 1925 to 89 in 1940—an improvement of 39 per cent.

There was also a striking improvement in the dependability of locomotives during this period. In 1925 we had a total of 388 failures charged to freight locomotives. In 1940 this figure had decreased to 74—an improvement of 81 per cent. Likewise the improvement in miles per freight failure more than tripled. In 1925 it was 34,892 and in 1940 it had increased to 114,970.

These improvements in locomotive efficiency and dependability have also been accompanied by a decrease in the cost of maintenance. The cost of repairs per million tractive-power-pound-miles for all steam locomotives decreased from $7.35 in 1925 to $4.99 in 1940—a reduction of 32 per cent, and in the case of the Y-6 locomotives, which will be covered in detail later, the cost per million tractive-power-pound-miles is $1.77, based on a report of the cost of maintenance for a period of 56 months.

Contributed by the Railroad Division and presented at the Semi-Annual Meeting, Kansas City, Mo., June 16–19, 1941, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

MODERN FREIGHT LOCOMOTIVES MAKE IMPROVEMENTS POSSIBLE

How were these improvements made possible? By the use of modern freight locomotives! By designing locomotives that would pull more, run faster, have more availability and dependability, and at the same time, locomotives that would burn less coal and have less money spent for maintenance. That is a large order, but statistics prove that it is entirely possible.

The Norfolk and Western Railway has constructed 35 modern compound mallet locomotives, 2-8-8-2 type, known as class Y-6, at its main shops in Roanoke, Va.

This locomotive, see Fig. 3, develops a tractive force of 126,838 lb in compound and 152,206 lb in simple position and

TABLE 1 COMPARISON OF LOCOMOTIVE DATA, NORFOLK AND WESTERN RAILWAY, 1925 AND 1940

	Years		Change, per cent (+) Increase (—) Decrease
	1925	1940	
Gross earnings, dollars	105,218,991	105,228,621	— 0.009
Net earnings	26,565,292	31,383,976	+ 18
Gross ton-miles (thousands) (excluding locomotive and tender)	27,037,267	30,178,450	+ 12
Number freight locomotives used (freight engines—road service)	653	347	— 47
Average tractive force of freight locomotives (freight engines—road service), lb	60,653	88,947	+ 47
Gross ton-miles per freight-train-mile (excluding locomotive and tender)	2,613	3,805	+ 46
Average speed, train-miles per train-hour (freight)	12.3	15.4	+ 25
Gross ton-miles per train-hour (freight, excluding locomotive and tender)	32,212	57,984	+ 80
Pounds of coal per 1000 gross ton-miles (including locomotive and tender)	147	89	— 39
Number freight locomotive failures	388	74	— 81
Miles per failure, freight	34,892	114,970	+230
Cost of locomotive repairs per million tractive - force pound-miles, dollars	7.35	4.99	— 32

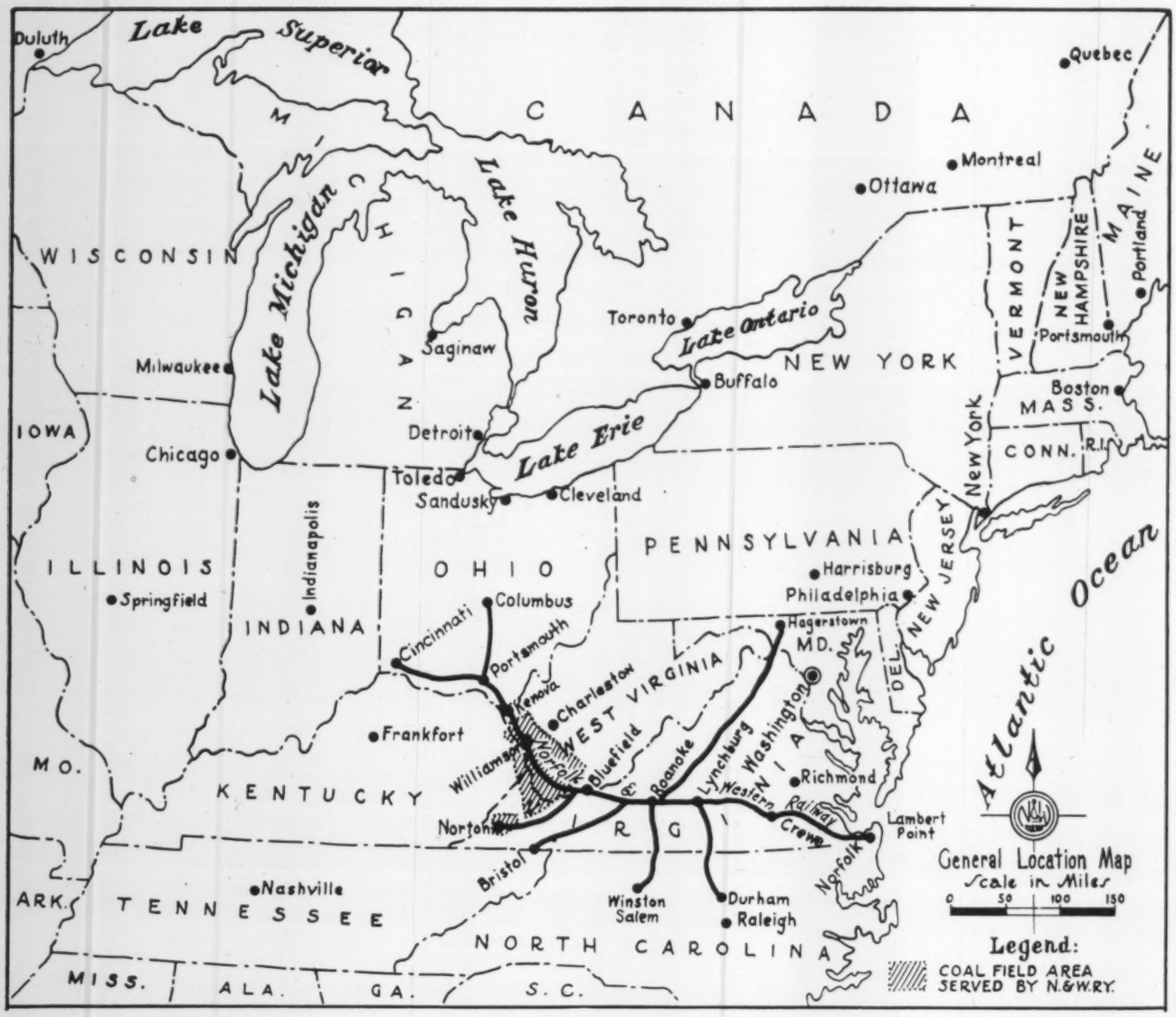


FIG. 1 MAP OF NORFOLK AND WESTERN RAILWAY

weighs 480 tons in working order including the weight of the loaded tender. It is 114 ft $10^1/_2$ in. long, measured from the pulling face of the coupler on the pilot of the locomotive to the pulling face of the coupler on the rear of tender. It has a rigid wheel base of 15 ft 9 in. for each unit and can negotiate curves up to a maximum of 20 deg.

The foundation unit for each locomotive is a cast-steel bed with the cylinders and back cylinder heads cast integral with the frames. The back or high-pressure frame unit is 32 ft $4^3/_8$ in. long and weighs 49,000 lb. The front frame unit is 32 ft 10 in. long and weighs 57,500 lb. An extension on the rear end of the front frame unit fits into a pocket in the high-pressure cylinder saddle and the two sections are pivoted together by means of a 7-in. diam vertical pin. Weight on the front unit is transmitted through one boiler slide bearing located between the second and third pair of drivers.

The engine truck driving, and trailer wheels are fitted with roller bearings. The engine and trailing truck bearings are the conventional outboard type. The driving-wheel bearings are a special design known as the "floating axle" type, see Fig. 5. The outer race of the bearing fits into a pocket counterbored in the wheel center and the inner race fits on an axle tube which encompasses the conventional axles. Driving boxes clamp around the axle tubes and ride in the frame pedestal openings. The weight from the spring rigging is transferred through the driving boxes, axle tube, and directly to the driving wheels.

The boilers on these locomotives are the radial stay type and are designed for 300 psi operating pressure. The maximum boiler diameter is $102^1/_4$ in. inside. The firebox is 14 ft $2^1/_8$ in. long by 8 ft $10^1/_4$ in. wide and has a grate area of 106.2 sq ft. The total heating surface is 7431 sq ft which is divided into 5656 sq ft of evaporative and 1775 sq ft of superheating surface. A low-water alarm is installed as a safety precaution to prevent a boiler explosion.

The driving wheels are 57-in. diam, the main wheels being the third pair in both units. The main and side rods, driving and truck axles, crank pins, piston rods, guides, and combination levers are made of medium carbon steel and are given a double normalizing and drawing heat-treatment to develop the best physical properties. The valve diameters are 14 in. on the high-pressure and 18 in. on the low-pressure.

There are four mechanical lubricators on each locomotive. Two are for valve oil and two for engine oil. Valve oil is used to lubricate parts subjected to high steam temperatures such as valves, pistons, slip joints, air pumps, and stokers. Engine oil

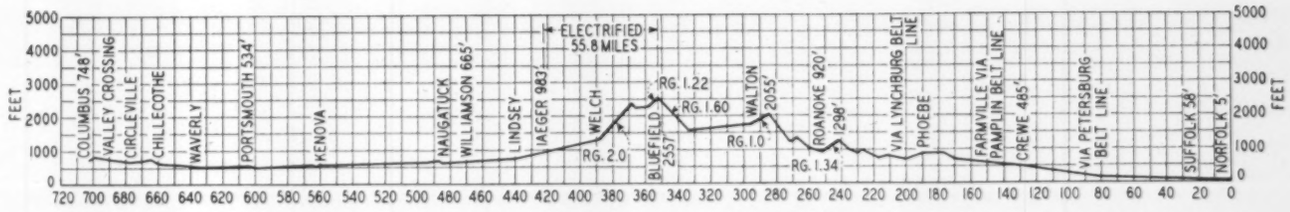


FIG. 2 CONDENSED PROFILE OF NORFOLK AND WESTERN RAILWAY, NORFOLK TO COLUMBUS

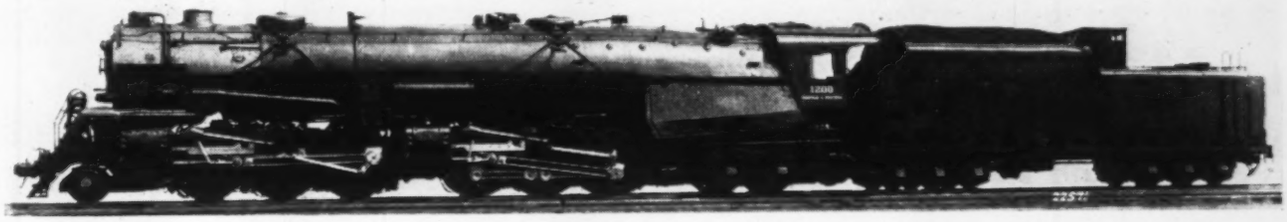
(Horizontal scale 1 in. = 40 miles; Vertical scale 1 in. = 2000 ft. Both scales reduced for purposes of reproduction.)

2-8-8-2 COMPOUND ARTICULATED CLASS Y-6
FREIGHT LOCOMOTIVE

152,206 lbs. (Simple) ..... Tractive Effort ..... 126,838 lbs. (Compound)

Cylinders	Two front 39" dia. x 32" stroke; Two rear 25" dia. x 32" stroke
Driving Wheels	Eight pairs 57" diameter
Wheel base (engine and tender)	103 ft. 8¼ in.
Weight of engine, in working order	582,900 lbs.
Weight of engine and tender, in working order	961,500 lbs.
Boiler Pressure	300 lbs.
Water Capacity of Tender	22,000 gals.
Coal Capacity of Tender	26 tons
Overall length (engine and tender)	114 ft. 10½ in.
All wheels equipped with roller bearings.	
Locomotive bed cast in two huge steel castings, weighing 106,500 lbs.	

FIG. 3 2-8-8-2 COMPOUND ARTICULATED FREIGHT LOCOMOTIVE CLASS Y-6



2-6-6-4 SIMPLE ARTICULATED CLASS A
FREIGHT AND PASSENGER LOCOMOTIVE

Tractive Effort ..... 104,500 lbs.

Cylinders	Four 24" dia. x 30" stroke
Driving Wheels	Six pairs 70" diameter
Wheel base (engine and tender)	108 ft. 7¼ in.
Weight of engine, in working order	570,000 lbs.
Weight of engine and tender, in working order	948,600 lbs.
Boiler Pressure	275 lbs.
Water Capacity of Tender	22,000 gals.
Coal Capacity of Tender	26 tons
Overall length (engine and tender)	120 ft. 7½ in.
All wheels equipped with roller bearings.	
Locomotive bed cast in two huge steel castings, weighing 110,925 lbs.	

FIG. 4 2-6-6-4 SIMPLE ARTICULATED FREIGHT AND PASSENGER LOCOMOTIVE CLASS A

is used for lubrication of shoe and wedge faces, guides, boiler slide bearing, hinge pin, and spring and brake rigging. The total number of points lubricated by these four lubricators is 210.

The tender has a capacity of 26 tons of coal and 22,000 gal of water. It is built on a one-piece cast-steel (water-bottom) frame which forms the bottom of the tank. Two six-wheel trucks with 33-in. heat-treated wrought-steel wheels and 6½ in. × 12 in. journals are used.

Some of the special features include stoker, power reverse gear, feedwater heater, automatic cab signals, speedometer, multiple-valve front-end throttle, intercepting valve, type "A" superheater, and roller-bearing valve gear.

One of the best indications of the dependability of a locomotive is the turning time, provided business is heavy enough to create a demand for power. The class Y-6 locomotive operates out of a roundhouse in Roanoke (Shaffers Crossing), in pool service. The locomotives are actually dispatched in five

directions, but because the locomotives dispatched to Bristol and Bluefield run over the same tracks for 40 miles they are combined and shown on the report as dispatched west. The total dispatchments for the month of December, 1940, and the average motive-power turning time for the class Y-6 locomotives are as follows:

	East	West	North	South	Total
Number of Y-6 locomotives dispatched	221	308	109	103	741
Average motive-power turning time	3:48	3:39	4:26	3:23	3:47

The locomotives that operate north of Roanoke are in train-control territory. There are 18 of the Y-6 locomotives equipped with train control and they are operated on this district. No special group of engines is assigned to the Shenandoah division (north) and the engines operate in a pool. The only requirement is that the locomotives dispatched north must be equipped with train control. When you consider there are only 35 class Y-6 locomotives, the dispatchment of 741 locomotives per month with an average turning time of 3 hr and 47 min is good performance. It must be borne in mind that Roanoke is the maintenance point for these locomotives and that the turning time at the outlying terminals is substantially lower. The locomotives dispatched north operate a total of 480 miles from the time they are dispatched from Roanoke until returned to that point without any substantial maintenance work. This turning time at Shaffers Crossing represents regular practice for turning and maintaining the class Y-6 locomotives and no attempt was made to select a month having unusually good performance.

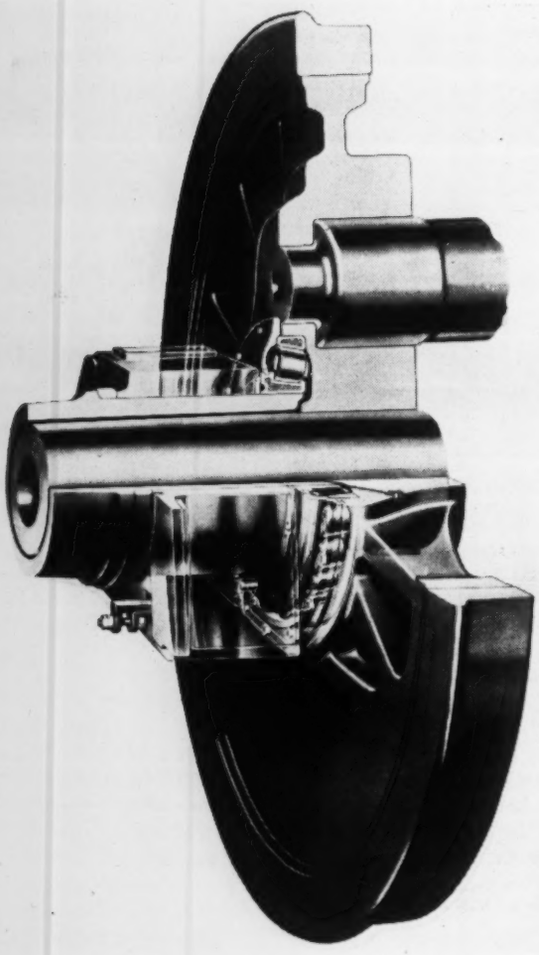


FIG. 5 FLOATING ROLLER-BEARING LOCOMOTIVE AXLE

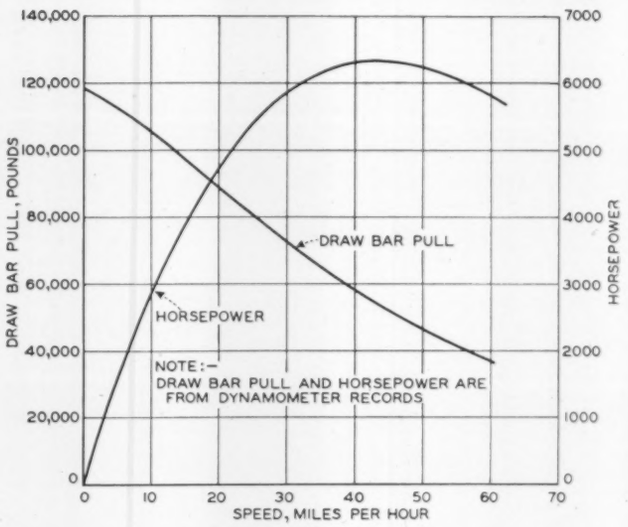


FIG. 6 HORSEPOWER AND DRAWBAR PULL VS. SPEED, CLASS A LOCOMOTIVE

It may be thought that the class Y-6 locomotive is good for drag service only. Such is not the case. It is assigned to both fast and slow freight service and in good operating territory it attains top speeds of 45 to 50 mph with tonnage trains.

CLASS A LOCOMOTIVE DESCRIBED

The Norfolk and Western simple articulated locomotive of the 2-6-6-4 type, class A, is illustrated in Fig. 4. The road has 10 of these locomotives and the first has been in service since 1936. This locomotive with its tender weighs 474.3 tons in working order and develops a calculated tractive force of 104,500 lb. It is 120 ft $7\frac{1}{2}$ in. long over-all and is equipped with a water-bottom tender that has a capacity of 22,000 gal of water and 26 tons of coal. This locomotive has 70-in. drivers and a rigid wheel base of only 12 ft 4 in. for each unit and can negotiate curves of 20 deg at slow speeds. Like the Y-6 locomotive it is equipped with cast-steel bed frames, roller bearings on the engine truck, drivers, trailing truck, and tender, extended mechanical lubrication, lubricating a total of 227 points, multiple-valve front-end throttle, type "E" superheater, feedwater heater, and roller-bearing valve gears.

The maximum sustained horsepower at the drawbar as determined by dynamometer records is 6300 at 45 mph. The maximum rate of evaporation recorded is 116,055 lb of water per hour or approximately 14,000 gal per hr. The maximum sustained combustion rate is 7 tons per hour. This is at a rate of 115 lb of coal per square foot of grate area per hour. For curves of tractive force and horsepower see Fig. 6.

This locomotive handled a 7500-ton train on level tangent track at 64 mph as determined by dynamometer tests. These locomotives are assigned to both fast-freight and heavy-passenger service and they attain top speeds of 60 to 65 mph in regular service in high-speed territory with tonnage trains. These locomotives average 8540 miles per month.

The performance of both the class Y-6 and A locomotives has been so successful that we are now modernizing a group of 2-8-8-2 compound mallet locomotives, class Y-5, which are only 10 years old. The modernization consists of applying cast-steel bed frames, installing roller bearings on the engine truck, driving, and trailing truck wheels, and applying mechanical lubrication. There are 19 locomotives in this group which will be modernized.

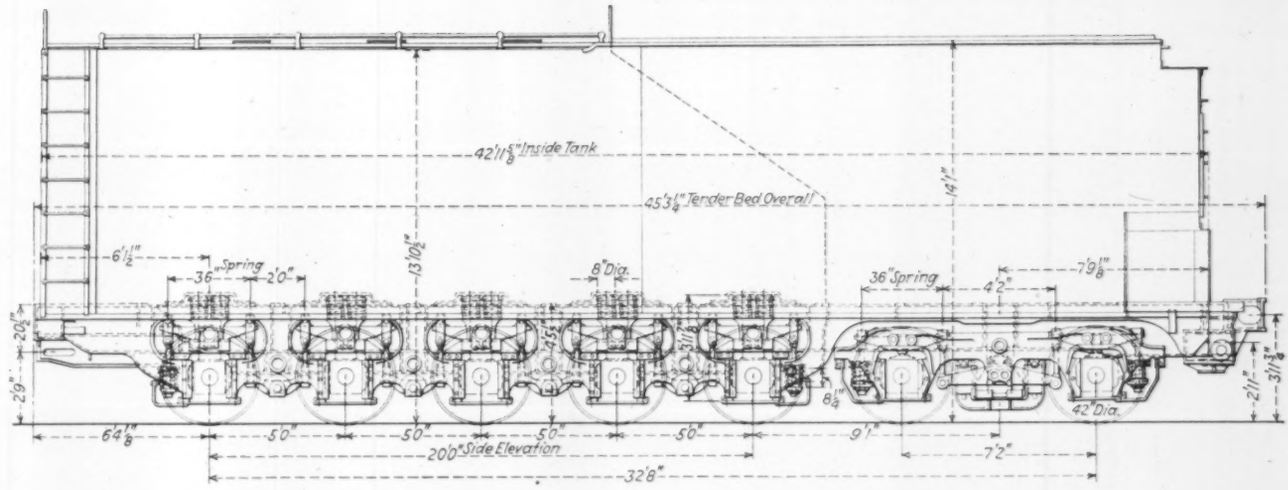


FIG. 1 ELEVATION OF UNION PACIFIC 14-WHEEL TENDER SHOWING EQUALIZATION SYSTEM AND COIL SPRINGS OVER EACH JOURNAL BOX

Advance in LOCOMOTIVE TENDER DESIGN

By M. C. HABER

MECHANICAL ENGINEER, UNION PACIFIC RAILROAD, OMAHA, NEB.

DURING recent years many studies have been made to develop economies to meet increasing operating expenditures and costs on all major American railroads. Among the avenues remaining to reduce these costs on the Union Pacific Railroad there were:

1 Modification of existing motive power to produce higher horsepower output.

2 Design of improved types of new steam locomotives based on

(*a*) Developments and experience with use of roller and needle bearings
(*b*) Improved high-tensile alloy steels
(*c*) Higher cylinder horsepower capacities
(*d*) Improved types of tenders with larger water and coal capacities which would not require extensive modifications or changes in roadway structures, roundhouses, and coal and water facilities, with reduced weight, and decided reduction in maintenance cost and time out of service for repairs

The first tenders in service on locomotives on the Union Pacific Railroad had a water capacity of 1600 gal. The need of more water was recognized as early as 1867 when water capacity of tenders of new locomotives ordered was increased to 2000 gal. These early locomotives on the Union Pacific Railroad were all wood burners. The water and coal capacities of tenders were increased progressively from 1600 gal of water 75 years ago to 25,000 gal of water and 32 tons of coal, including heap, on tenders built in 1941 for 20 new 4-8-8-4 type simple articulated locomotives.

Contributed by the Railroad Division and presented at the Semi-Annual Meeting, Kansas City, Mo., June 16–19, 1941, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

These tenders are of the 4-10-0 type wheel arrangement, with 42-in-diam wheels and with journals equipped with roller bearings. A four-wheel swiveling, laterally controlled, outside-bearing guiding truck is located at the forward end as illustrated in Fig. 1. Behind this truck are five pairs of wheel assemblies, also laterally controlled in pedestals cast integral with the water-bottom tender bed.

The four-wheel truck, of the equalized type, with a roller centering device provides for 17 per cent initial and constant resistance, as illustrated in Fig. 2.

The five pairs of pedestal wheels are equalized together, with one semielliptic spring and two coil springs over each box. The front and back end of each equalizing system is attached to the frame through cushioning coil springs. Between each box and the semielliptic spring saddle is a centering device to resist lateral movement, shown in Figs. 2 and 3.

With this spring rigging equalization a three-point loading is obtained, one point being at four-wheel truck center plate and the other two points in the pedestal group equalization assembly.

Each pedestal face of the fixed group is provided with a hardened spring-steel pedestal liner assembly of two plates between which is bonded one-half inch of rubber arranged to permit one-half inch of lateral movement. Additional lateral movement provided between the box and pedestal liner assembly, permits a total lateral movement of $1\frac{1}{4}$ in. on each side of axles Nos. 3, 4, 5, and 6, and $\frac{3}{4}$ in. on each side of axle No. 7, as shown in Fig. 3.

This tender construction necessitated the development of suitable brake rigging. A clasp type of brake was developed for the lead truck, employing two brake cylinders, one mounted on each side of the truck frame. For the ten-wheel fixed group,

clasp brakes are likewise used, each pair of wheels being braked by one brake cylinder suspended from the underside of the tender bed. All brake rigging pins are fitted with lock nuts, antirattling devices, and provision for lateral displacement of wheels. Two single brake shoes 15 in. long are provided for each wheel to reduce brake-shoe pressure per unit area. Soft-grease lubrication is provided for the brake rigging, where required.

The tender bed casting is provided with openings opposite the semielliptic springs, equalizer pins, and foundation brake parts to facilitate inspection and replacement of parts.

This new type of construction made possible the elimination of a number of detailed parts and reduced the total weight approximately 15,000 lb below that of a conventional tender design of equal capacity. The light weight of these tenders is 165,500 lb and the loaded weight is 438,750 lb.

Numerous tests were conducted with tenders of this type, which were placed in service in 1939, to determine whether or not modifications would be required to meet any and all operating conditions. No revisions of design were found to be necessary.

With 17 per cent initial and constant resistance, a full tank of water and no coal, the tender passed entirely through an 18-deg curve without superelevation. No wheel left the rail and there was no indication of tender derailing. The maximum movement of the tender-truck center casting was $3^{15}/_{16}$ in. to left on rocker plate.

Tests were also made to determine whether the tender would derail if spring hangers on any of the five pairs of pedestal

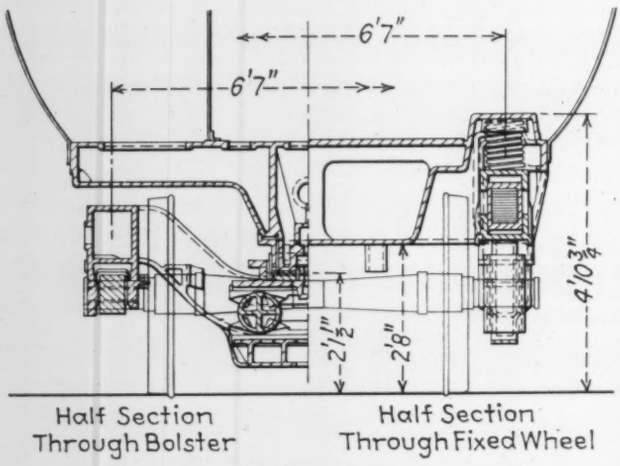


FIG. 2 HALF SECTIONS THROUGH TENDER BED

wheels were to break in service. This was done by operating the tender with different spring hangers disconnected. In operations with varying amounts of coal and water, ranging from empty to full load, no case developed in which the tender wheels showed indications of lifting or derailing in either forward or backward movements.

No vertical flanging of any of the rolled steel wheels has developed during two years of service operation, and the mileage between turning of wheels for tread wear is several times greater than mileage obtained for wheels under other large-capacity tenders with 36-in-diam rolled-steel wheels and two six-wheel swiveling trucks.

Furthermore, tenders operating on the Union Pacific Railroad, equipped with conventional six-wheel equalized trucks, required complete renewal of all brake rigging pins and bushings at the end of the first year in high-speed passenger service, whereas the brake rigging pins on tenders of this later design,

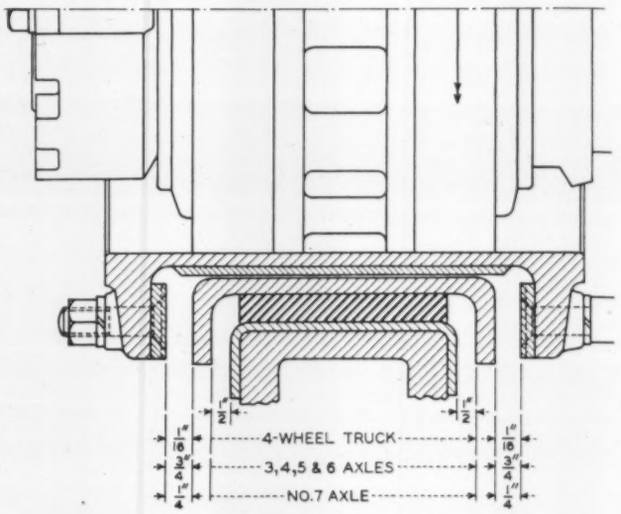


FIG. 3 SECTION THROUGH PEDESTAL LINER ASSEMBLY

in the same service, have operated over a period of two years with the original pins and bushings still in service and with practically no wear.

Results obtained in actual service with this type of tender definitely proved that, because of the good riding qualities, reduction in wear of moving parts, and increased mileage of rolled-steel wheels, a substantial reduction in maintenance costs was obtained. In addition operating costs were reduced owing to increased capacity resulting in fewer stops for coal and water and reduced axle loads resulting in less wear and tear on roadway structures and tracks.

Heat-Treatment of Molybdenum High-Speed Steels

(*Continued from page 706*)

LIST OF MANUFACTURERS OF CONTROLLED-ATMOSPHERE FURNACES

In the selection of atmosphere-controlled furnaces, the purchaser should secure a guarantee that the furnace selected will satisfactorily harden molybdenum high-speed steels for his particular needs without the use of surface-coating materials.

The following firms are manufacturers of controlled atmosphere furnaces and upon request will supply bulletins and complete descriptions of their equipment. They will also supply references of those who are successfully hardening molybdenum high-speed steels in their controlled-atmosphere furnaces. These firms also extend engineering and metallurgical assistance to furnace users as well as heat-treat samples or permit those interested to heat-treat their own samples in the respective equipment under consideration: General Electric Co., 1 River Rd., Schenectady, N. Y.; C. I. Hayes, Inc., 75 Baker St., Providence, R. I.; Hevi Duty Electric Co., 4212 West Highland Ave., Milwaukee, Wis.; Lindberg Engineering Co., 221 North Laflin St., Chicago, Ill.; The Sentry Co.,[5] Foxboro, Mass.; Surface Combustion Corporation, 2375 Dorr St., Toledo, Ohio.

[5] The following manufacturers of conventional type furnaces use the Sentry Co. method for atmosphere control: American Electric Furnace Co., 27 Von Hillern St., Boston, Mass.; American Gas Furnace Co., Elizabeth, N. J.; Barkling Fuel Engineering Co., 402 No. Paulina St., Chicago, Ill.; Charles A. Hones, Inc., Baldwin, L. I., New York; and Dempsey Industrial Furnace Corp., Springfield, Mass.

QUALIFICATIONS *for* OPERATING RESPONSIBILITIES

By ALEX D. BAILEY

COMMONWEALTH EDISON COMPANY, CHICAGO, ILL.

WHEN I was asked to prepare a paper on this subject, my first impulse was to ask to be excused because I was too busy and did not have the time to do the subject justice; but on second thought I accepted the assignment because it would afford me another opportunity to "ride my hobby" and repeat again the arguments I have written and talked about for many years. My approach in this case, however, was different. I thought that I might possibly be in a rut, so I asked two young engineers[1] in the organization, each of whom has had fifteen years or more of operating experience since leaving school, to write a paper on this subject, each independently of the other.

When the papers were finished, the three of us sat down and read them aloud. The results were most interesting. Each one had approached the subject and treated it in a very different manner from the others and yet as I took notes while each paper was being read, I found that each writer developed similar fundamentals and that each in his own way had emphasized the same points to a surprising extent. The resulting discussion was good for all of us, and this paper is the result of that discussion. I found that these two men were generally interested in the same qualifications which I had in mind, although the emphasis placed on any one may have varied slightly with each personal presentation.

WHAT ARE OPERATING RESPONSIBILITIES?

I shall first define the subject assigned as I understand it. The term "Operating Responsibilities" is assumed to mean the increasingly important responsibilities of one who is taking a part in or directing the technical operations of a service organization such as a transportation system, a communication system, a gas or electric utility, or some other organization of a similar character. The function of such an organization is similar to that of the production department in the manufacturing field and the discussion which follows might in many cases be applied to such an activity.

It is manifestly impossible to list all the qualifications desirable for any position of importance; and even if this were possible, such a list of abstract traits would fall far short of telling the whole story. The list might be so long as to be appalling and yet it would leave out much that was necessary but which words might be lacking to express.

One way to describe the qualifications desirable for any position in which an engineer may find himself, or to which he may aspire, would be to describe the job and its duties, practices, routines, and future possibilities, and from them let each one draw his own conclusions and place his own emphasis as he pleases. A specification for succeeding job classifications through which he would progress might be illuminating as this would show the change in the nature and character of his duties and might be a "lamp unto his feet." The difficulty, however, is that no two might travel exactly the same path nor reach the same goal, and yet each might be successful in his chosen work. We humans like to feel that we are individuals and prefer to work out our individual destiny as we wish without being regimented, directed, and fitted to a definite pattern. While it is true that we may have the same goal as others in our field of activity we prefer to follow our own inclinations and make our own path in reaching it.

A better way to attack this subject might be to give the history of the trained engineer in this particular activity and by following his duties, his responsibilities, and his progress in a more or less general way, create a picture which could be interpreted in terms of qualifications for the particular sequence of jobs. It would be a moving picture, of course, with changing action, and in each individual case, if we only know the details, might have all the humor and possibly tragedy of a melodrama. In this manner I think I can picture the requirements and the important qualifications better than to list these qualifications in an abstract manner. To say that a man must be reliable or honest or energetic or imaginative is not enough, even though we agree he should have all these characteristics and many more.

FUNDAMENTAL QUALIFICATIONS

I will say, however, that the prime qualification is that he must be an engineer. He must have the aptitude for mechanics and the love of mechanical equipment; and he must get pleasure and satisfaction out of making it perform in detail and as a whole. He must have the ability to perfect the organization of his part of the work both technically and in personnel. Then he must be a humanitarian since he will have to depend on the human organization to get results with the physical plant. This is truer today than ever in the history of industry. A comprehensive specification would be that he must be a good engineer in both branches—the technical and the human.

A PICTURE OF THE JOB

I should like to draw a rough picture of the young engineer's progress in the operating field and in the course of the narration call attention to particular requisites at particular points.

The operating department of an electricity-supply company has one important feature which differentiates it from all others, namely, that its product must be made and delivered instantly if, as, and when demanded, and in any amount. There is no inventory of material built up during quieter periods to take care of the "spring rush." The quality of the product must be uniform to accuracies little understood or appreciated by the ordinary customer. "The show must go on," the proud slogan of Thespians for generations, refers to a particular performance at a particular time. "The mails must go through" means a particular delivery at an assigned place. But the slogan of the electric utility, "Constant voltage and frequency on all the customers' services, all the time," is infi-

[1] J. R. Michel, Efficiency Engineer (Purdue, 1922). Earle Wild, Load Dispatcher (M.I.T., 1924).

Contributed by the Committee on Education and Training for the Industries and presented at the Semi-Annual Meeting, Kansas City, Mo., June 16–19, 1941, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

nitely more exacting. It applies equally to the continuous operation of a small clock in your bedroom which wakens you in the morning and to the intermittent and irregular operation of the rolls in a large steel mill or the exacting demands of the pumps of an urban water system.

The uninitiated may say that such a utility does not have the spur of competition exerting economic pressure continuously, but if he investigated he would soon find that it has competition in a variety of forms, and that in addition its operations and costs are under the constant surveillance of a regulatory commission.

Because of these features, the operating department of such an organization seems to be a good example on which to proceed with our discussion, as these peculiar characteristics demand and serve to emphasize the qualifications which are important to other service organizations and industries generally.

To almost anyone except the operating man himself, operating might seem a humdrum existence, attractive principally to those who are inclined to be easy-going, with little ambition and less initiative. This may account for the fact that up to a few years ago, relatively, engineering graduates preferred to enter research or design work, for they thought that those fields offered the greatest opportunity for their technical ability. Then too, the educated engineer was not welcomed by those already in operating positions who, lacking the advantages of a technical education, and having acquired certain skill in "the school of hard knocks" by bitter experience, resented the usurpation of their field. The situation was similar to that which we are told existed in the steel industry when metallurgists first began to develop specifications for the manufacture of steel. One "old-timer" is reported to have expressed himself along this line: "Those damned chemists are going to ruin the steel business!"

Those educated and trained engineers who did get into operating work, however, and survived the initiation they received, soon made a place for themselves and their successors. They brought to the job the ability to analyze the performance of equipment as it had never been done before. They knew how to attack and to solve the technical problems which increased in number and detail. They knew the value of exact information and maintenance of proper records and from these developed exact control of detailed processes; and as a result of this detailed information and the study of operating performance and results, improvements in design were stimulated. Each improvement in turn brought new problems and opened new avenues for further improvements. This was followed by improved control of manufacturing processes with improved products, lower costs, and less arduous labor on the part of the personnel.

In a large organization, operating work is anything but monotonous, though we shall have to admit that it does require men possessing certain characteristics which fit them for this type of work. The temperamental individual and the nervous man have no place in it. The young man undertaking this work must be sound physically and mentally and prepared to work long hours on jobs that will call for the best he has in both regards. He soon learns that the cardinal principle of the organization is that production must continue at all times and at all odds; there must be no interruptions. He has no time for moods, temperament, grudges, or animosity. Like the equipment with which he works, he must above all be reliable. He must be steady and maintain his mental equilibrium under the most trying conditions. He must be prepared to accept responsibility in increasing doses.

The young engineer effects his entrance into operating work through technical knowledge and ability, and in addition to the training and habits of his profession he must have a good fundamental technical education in order successfully to pass through the first period of experience in an operating position. He must expect to learn the operation of the plant from the ground up, and no work in connection with that training is too menial or too dirty for him to tackle. He must have sufficient imagination at the outset to see beyond the immediate job on which he is engaged. However, he will soon be given opportunities for putting his technical education to practical use and will be assigned jobs of minor importance in checking the performance of equipment or in performing routine operations which require more than ordinary technical skill.

The operation of a large, smooth-running organization is a beautiful thing to watch, but one must never let himself be deluded by the thought that such things just happen. The young man, if he is observant, will be impressed by the fact that emergencies do not arise and will soon learn that this is so because they have been anticipated; and that preparations have been made to handle immediately any unusual condition that may arise. He must learn the equipment in his charge down to the finest technical detail and know its possibilities, its weaknesses, and its shortcomings so that he may make this equipment produce up to the full limit of its mechanical possibilities. He will also be able to anticipate possible troubles and failures and by preparing for them avoid serious interruptions. He must have imagination for that much at least.

In connection with the operation of the equipment in his charge, he must not only have a thorough understanding of the function of each detailed part, but he must as thoroughly understand the rules and regulations governing its operation. Concentration on each act is essential, for mistakes may be costly, owing to the wrecking of equipment, and in the case of the operation of an electrical system may hazard his own life or that of his fellow workmen. This is no job for a dreamer whose wits might be wool-gathering at a critical time; nor for one whose senses are dulled by dissipation of any kind. Those with whom he works will be the first to criticize and to condemn him for carelessness and no supervisor will tolerate it.

DEVELOPMENT OF PERSONALITY

During this process he will learn how to "get along with people," whether it be fellow workmen or the "boss," and if he is adaptable he will soon fit himself into his place in the organization "without undue noise or wear" in accordance with the best machinery specification. He will find that those with experience can provide many short cuts and can help him over difficult places. He on his part must make his contribution to those who help him and to those who in turn will look to him for help.

As he gradually masters the technical details of his job and by experience acquires a sense of the true value of his position and the various operations which he has studied, he will be placed in charge of a certain operation involving the supervision of others. Here is the real test of his ability, and though he may not realize it, he will be watched more carefully than at any other time. This is his apprenticeship in leadership. This is his opportunity to show whether he has those personal qualifications which distinguish the successful manager. In his early training, as was previously stated, he learned how to get along with people; now he must learn how to make people get along with him.

In addition he begins to get an appreciation of the economic importance of the work he has been doing and which from now on he must assist in planning. While his previous problems started and ended with calculations in technical terms, these have been gradually expanded until the answers are translated into dollars. Almost before he realizes it, he will uncon-

sciously translate technical reports and technical terms into monetary values.

It is at this stage of the game that he establishes a reputation which will probably stay with him as long as he lives and that he will form habits of conduct which will fasten themselves on him for the rest of his life. It is exceedingly important, therefore, that he be careful in his conduct, that he keep his chin up, that he accept trouble with a grin, but nevertheless with determination to maintain his mental equilibrium. He must learn to stand up for his rights and for what he considers the proper conduct of his work until he is shown otherwise, and in that case must accept better advice gracefully and wholeheartedly. After he is proved wrong he must admit it, but he must avoid being a "yes man," for no one has confidence in that type of individual.

During all this time he will have been selling himself to his superiors and to his fellow workmen. His early reports will be watched with interest to see if he has clarity of thought and to see whether or not he is able to tell his story in a few words. The spoken word, as well as the written, is important, and unless he is able to express himself clearly both orally and in writing, he will be under a severe handicap. If he has a complete understanding of the details of his work, he will be enabled to withstand the barrage of questions with which his early reports and suggestions may be received; so let him be particularly careful in these early stages of his experience in order that he may build up a reputation for thoroughness, reliability, and open-mindedness which will stand him in good stead later on. He will discover later that the questions and arguments to which he has been subjected have been the finest training in the world, and that his ability to stand up in defense of his arguments, all based on a complete knowledge of the subject under discussion, will give him confidence in himself which will be of inestimable value.

RELATION OF OPERATING TO OTHER DEPARTMENTS

The next step will naturally be to learn the relation of the work in which he is engaged to that of others; and he will possibly be surprised at the interdependability of one division or service on the others. He will also find that his work and his efforts may effect those of someone working beside him or in another division. He will acquire a balanced judgment based on experience and a respect for the efforts of his fellow workmen.

During this time he must improve his relations with those in the associated departments so that he will become better acquainted with the complete organization and will better understand the function of his department and the particular part of the organization in which he is personally engaged. He will learn by experience, probably occasionally making mistakes, that the Golden Rule applies in interdepartment relations as well as it does between individuals, and that if he expects cooperation, he must give it.

In addition to this, he must keep in touch with what is going on outside of his organization in his chosen field and in associated activities. No one organization develops all the good things in an industry; and it is only by making outside contacts that one is able to get the benefit of improvements made by others or of their experience. The amount of time spent on these activities and the manner in which they are carried on will have to be left to the best judgment of each individual, and will be governed by conditions.

JUDGMENT ACQUIRED BY EXPERIENCE

Up to this point, particular emphasis has been placed on the engineer's technical qualifications, for these will be the means by which he will get started and during the early years, at least, work his way into the operating organizations. Through the discussion, however, has run an undercurrent of personal behavior and human relations; and gradually the economic features of each situation have begun to assert themselves. His engineering training will stand him in good stead in all these phases of his experience. The engineer is trained to deal with facts, and if there is one type of work that depends on facts, that job is an operating position. Theories are fine, but if they don't work out as predicted under actual operating conditions, they are worse than useless. The important thing is the operation immediately in hand and not some dream it is hoped will make good next year. When something goes wrong and the service is threatened, the operator is faced with a fact and not a theory. He may theorize later at leisure, but he must deal immediately with the facts confronting him. He must have vision and imagination to anticipate almost any trouble, large or small, that may happen to his equipment or his organization so that he will act instantly and instinctively do the right thing. He must first analyze the trouble before he can right it, but once having analyzed the situation, there is only one right thing to be done and dozens of wrong ways to do it. It is no time for snap judgment.

Because of all these facts and possibly because this type of work attracts a certain type of individual, experienced operating men, at least on the job or in discussions of their work, are considered a "hardheaded" lot. How could they be anything else under the conditions? Engineers are noted for their ability to deal with facts; but if there is any one branch of engineering activity that requires realists of the first degree, it is an operating job. To be sure, the operating man must have creative ability requiring the exercise of imagination and a complete understanding of the principles and theories underlying his particular activity, but he seldom has time to indulge in any protracted flights of fancy even if he were so inclined.

RESPONSIBILITY TO THE OPERATING FORCE

Engineers are belatedly beginning to realize the importance of the human side of their profession; and while I have always argued that more of this feature of their future work should be incorporated in their undergraduate work, let us assume that for the time being this must be acquired on the job after the young engineer leaves school.

In operating work he will soon realize the importance of the operating force. In operating work, human relations are more important than in any other type of engineering activity. The operating force determines the success or failure of the operating function of a large organization. Equipment, once installed, is a fixed thing, repeating its operations in a specified manner under specified conditions which are under control; but the operating force is continually changing in personnel, in position, in number, in responsibility, in temperament, and in a dozen other ways. Experienced men drop out and new ones come in. Each must be trained for his present position and be prepared for promotion. You can't learn how to operate a plant by reading a book about it any more than you can learn to swim by such a method. You have to get wet; and in spite of occasional unpleasant experience you finally become proficient and gain confidence; but a good teacher will save you many unpleasant experiences by showing you how to avoid them and by showing you correct procedure.

Men must be trained; men must be promoted; they must be taught to be constantly alive to their responsibility; but this must not be overdone to the extent that they get nervous and jumpy. The work they are doing may have many potential hazards which they must understand but of which they must have no fear whatsoever. When they learn that operating rules and regulations are for their protection, they will be the

first to insist that they are meticulously followed. Discipline must be enforced.

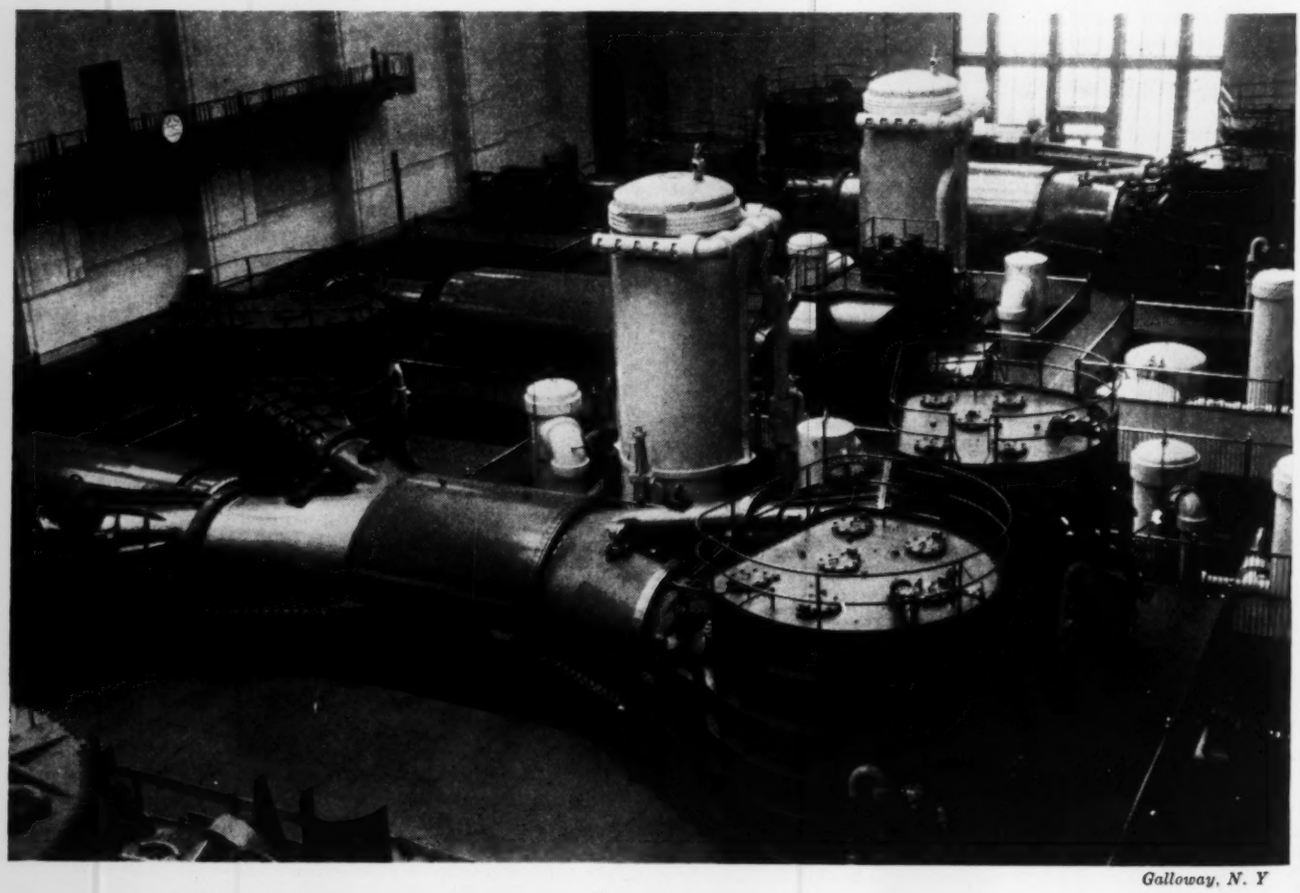
Somehow, sometime, the engineer must acquire some idea at least of the legal responsibilities of his job. Laws of all kinds, both state and federal, are being passed in increasing number, defining the economic and social responsibility of the employer for his employees. Industrial hygiene is attracting more and more attention. Occupational disease is a subject of common discussion. Health, safety, and comfort of the employees in an industry have become watchwords; and the effect of a given industry on the health, safety, and comfort of the community has become of increasing importance. Safety first has become a slogan, and a worthy one, both as applying to the employee and to the public.

These are problems of organization. Technical organization has always been an established function of the engineer. His education and training should also give him equal proficiency in perfecting organizations of men. There are more opportunities for showing ability in a smoothly operating personnel than in any performance of mechanical equipment. The operation of mechanical equipment may require skill, but the other requires skill and many other qualifications as well, including tact, fairness, firmness, loyalty, integrity, and so on, all of which distinguish the good manager. And here it might be well to inject a thought about leadership. We hear more and more that the day of the "driver" in industry has passed—let us hope that it never returns—and that supervisors must now be leaders. We may accept this blithely, but let us not forget that the role of the leader is much the more difficult of the two and requires higher qualifications. The engineer must accept this as one of his newer responsibilities.

I fear that I may have discouraged the young engineer with this lengthy, detailed picture. I hope not. What I have outlined may represent a lifetime of experience and effort. The building of character takes time, also the making of a reputation, but if the engineer will apply to his own personal case the analysis he is accustomed to apply to technical problems and then reaches his conclusions with a generous application of good common sense, he will come out all right.

As I said before, to list the qualifications of a good operating man in an abstract manner begs the question. Name for me any man who has rendered a real service to mankind and then try to list his qualifications. There is always something beyond words to describe. Maybe it is personality, which again is a comprehensive word difficult to define. We do know, however, that successful men succeeded because they were working on something they enjoyed doing; they put their best into it because they enjoyed the effort; they were fitted for their work by aptitude, personality, and force of character which enabled them to succeed in their chosen field of endeavor. Neither you nor I can list all of their qualifications. Maybe we can cover it all by saying that they were engineers who lived up to the principles, the ethics, and the ideals of their profession.

The operating field is an interesting and promising one for the engineer who by aptitude may be attracted to it and who in addition to his technical qualifications has the imagination, the persistence, and the creative ability to look past the initiation period when his work may seem circumscribed and detailed, and during which time he may feel that he is merely an unimportant cog in a large machine. Since successful operating work depends on the actions and reactions of individuals as well as of machines, the successful engineer in this field must also possess those qualifications difficult to define which are so necessary in human relations.



Galloway, N. Y

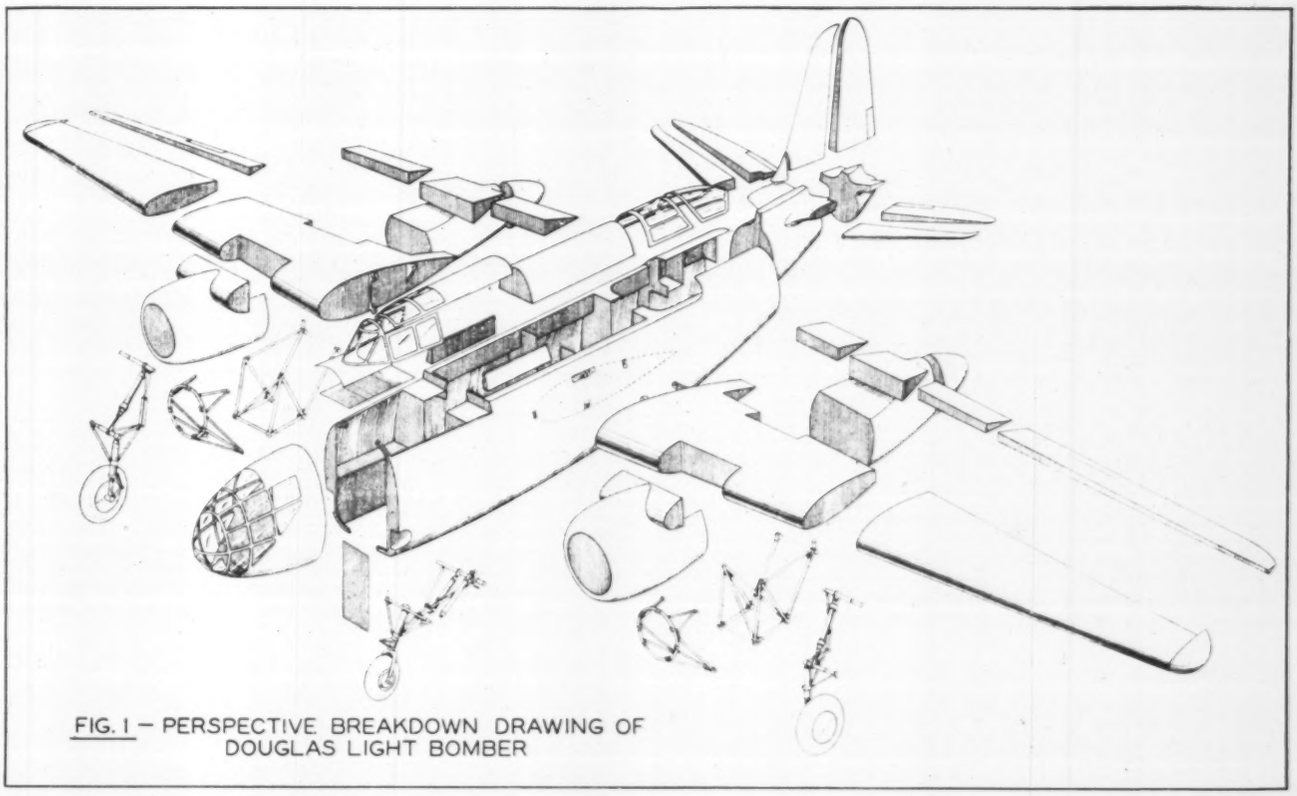


FIG. 1 – PERSPECTIVE BREAKDOWN DRAWING OF DOUGLAS LIGHT BOMBER

PRODUCTION ILLUSTRATIONS SPEED AIRCRAFT ASSEMBLY

By GEORGE THARRATT

DOUGLAS AIRCRAFT CO., INC., SANTA MONICA, CALIF.

THE Production Illustration Group of the Douglas Aircraft Co., Inc., specializes in cutaway three-dimensional drawings which portray in simple fashion the manufacturing details of airplanes and greatly speed the planning and operation of assembly lines for mass production. Because illustrations of this type are more readily understood than the customary blueprint, the problem of training hundreds of workmen is simplified and time is saved in the shop. The illustrations, called "Illustrated Job Tickets," give the workman a clear picture of the job as he will see it on the airplane, together with a list of parts necessary to be assembled, a list of nuts, bolts, screws, and clips to attach the parts, and a list of tools to do the job. Typical illustrations are reproduced and described.

PRODUCTION BREAKDOWN DIAGRAMS

Fig. 1 is a perspective diagram of the entire airplane showing the major structural subassemblies into which it is divided for manufacturing purposes. This diagram is prepared early in the preliminary design stage in consultation with the Engineering Production Design Group and the Tool Design Department, and from then on is used by the Engineering Department as a basic breakdown for structural design and functional installation design, and by the Tool Design Department in a like manner for the design of major jigs, tools, and fixtures. Copies of this breakdown diagram are sent to the engineering supervisors and leadmen concerned; also to lofting, tooling, production planning, estimating, inspection, material division, assembly-line coordinating supervisors and, upon request, to other departments.

STRUCTURAL UNIT BREAKDOWN SKETCHES

Each structural subassembly as shown on the production breakdown diagram is illustrated separately in perspective, Fig. 2, and further broken down into manufacturing units. This breakdown is also made in consultation with the Production Design Group and the Tooling Department. The work is done during the preliminary design stage; the sketches are used by the Design Group as a guide for structural and detail design and by the Tooling Department for the scheming of subassembly jigs, tools, and fixtures.

FUNCTIONAL INSTALLATION SKETCHES

Perspective drawings are made of all functional installations (e.g., flight controls, hydraulic systems, fuel systems, and con-

Based on an address delivered at San Diego, Calif., July 11, 1941, before the Los Angeles Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

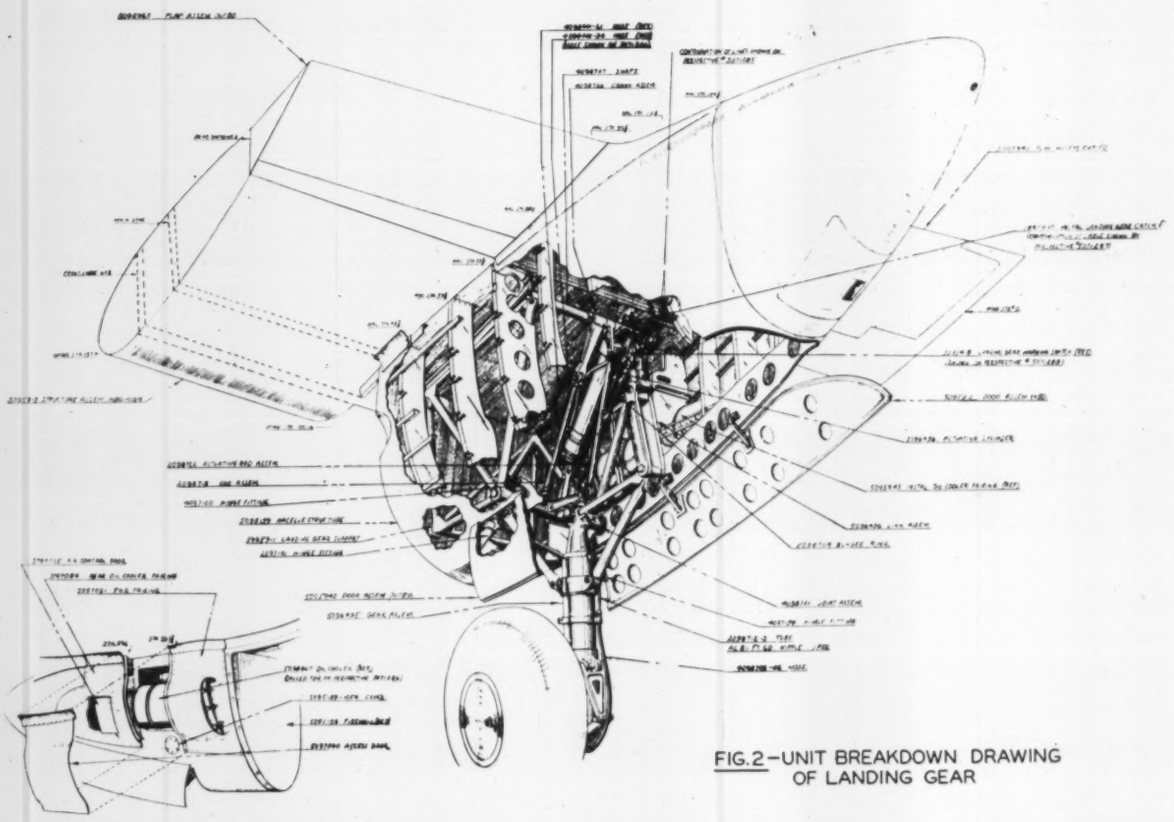
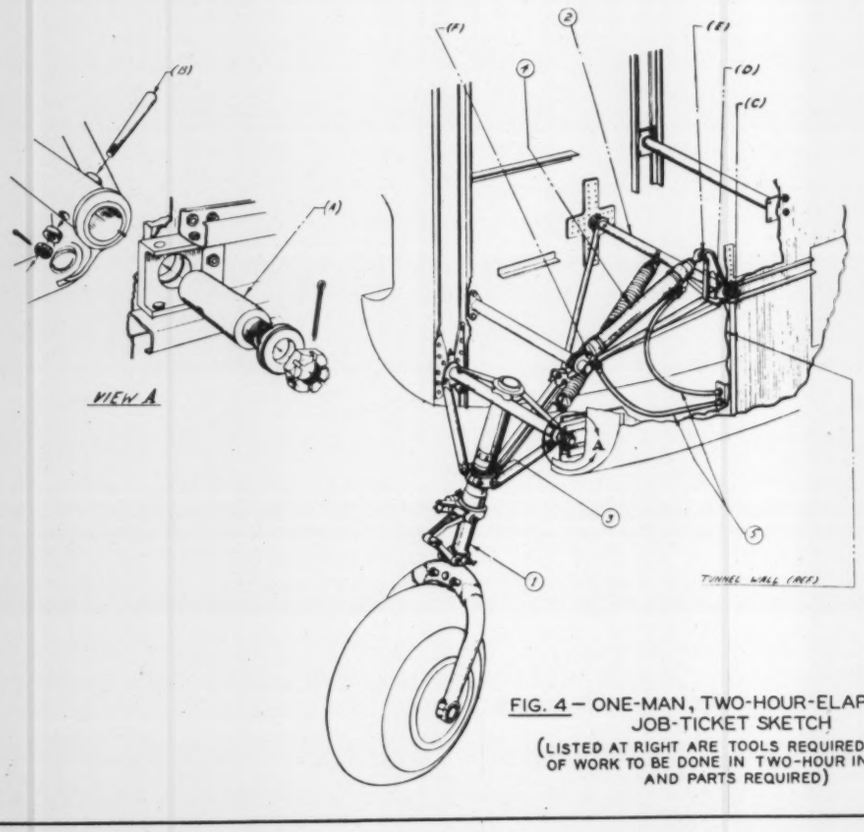


FIG. 2—UNIT BREAKDOWN DRAWING OF LANDING GEAR



JOB TICKET NO 1812-22 MODEL A-208

TOOL REQUIREMENTS

1/2" DRIVE RATCHET	1 PAIR DIAGONALS
1/2" DRIVE 1" SOCKET	1 PAIR PLIERS
3/8" DRIVE 1/2" SOCKET	1 BRASS BAR 18" LONG
3/8" DRIVE RATCHET	1 12 OZ. BALL PEEN
1 LARGE SCREWDRIVER	HAMMER

PROCEDURE

OPER. NO.

1. INSTALL #5096440 STRUT ASSEMBLY APPLY A THIN COAT OF PARKER THREAD LUBE TO PIN (A) BEFORE INSTALLING. INSTALL AS SHOWN IN DETAIL "A"

(A) 1098970	PIN	2 REQ.
1098967	WASHER	2 REQ.
AN380-4-4	COTTER	2 REQ.
AN320-10	NUT	2 REQ.
(B) AC386-4-13	TAPER PIN	2 REQ.
AN380-2-2	COTTER	2 REQ.
AN975-5	WASHER	2 REQ.
AN320-5	NUT	2 REQ.

2. INSTALL 5098971 MECHANISM ASSEMBLY USE SAME PROCEDURE AS IN STEP NO. 1

(C) 1098965	PIN	2 REQ.

3. CONNECT MECHANISM ASSEMBLY TO STRUT ASSEMBLY

AN29-36	BOLT	1 REQ.
S-102661489-108	SPACER	1 REQ.
AN320-9	NUT	1 REQ.
AN960-916	WASHER	1 REQ.
AN380-4-4	COTTER	1 REQ.

4. INSTALL 5096457 CYLINDER ASSEMBLY

(E) AN6-15	BOLT	1 REQ.
S-105960-8-375-624-749	SPACER	1 REQ.
AN310-6	NUT	1 REQ.
AN960-616	WASHER	1 REQ.
AN380-3-3	COTTER	1 REQ.
(F) AN6-14	BOLT	1 REQ.
S-105960-8-375-624-749	SPACER	1 REQ.
AN310-6	NUT	1 REQ.
AN960-616	WASHER	1 REQ.
AN380-3-3	COTTER	1 REQ.

5. CONNECT NOSE #4096400-21 & -18 TO CYLINDER

6. TIGHTEN AND SAFETY ALL NUTS AND BOLTS

FIG. 4—ONE-MAN, TWO-HOUR-ELAPSED-TIME, JOB-TICKET SKETCH

(LISTED AT RIGHT ARE TOOLS REQUIRED, SEQUENCE OF WORK TO BE DONE IN TWO-HOUR INTERVAL, AND PARTS REQUIRED)

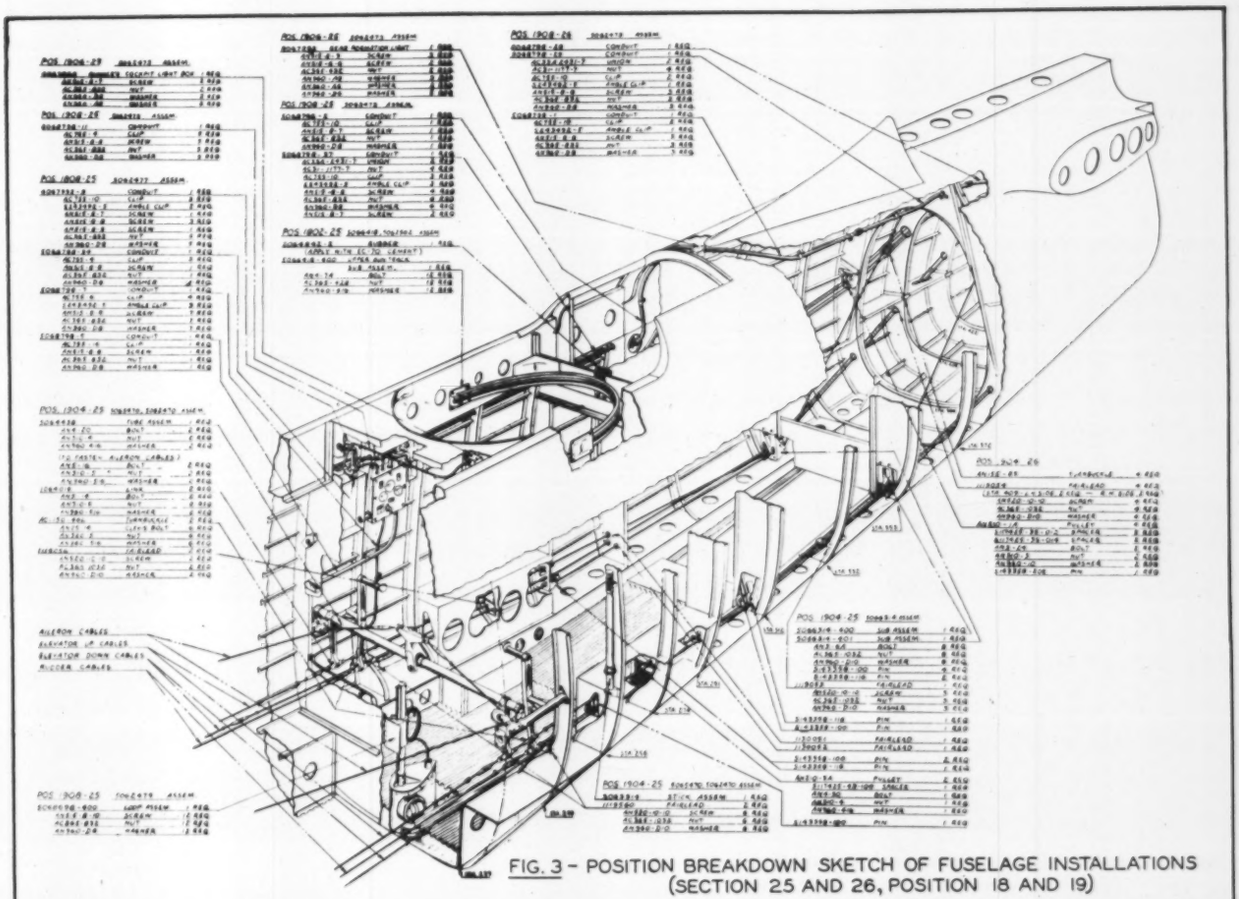


FIG. 3 – POSITION BREAKDOWN SKETCH OF FUSELAGE INSTALLATIONS (SECTION 25 AND 26, POSITION 18 AND 19)

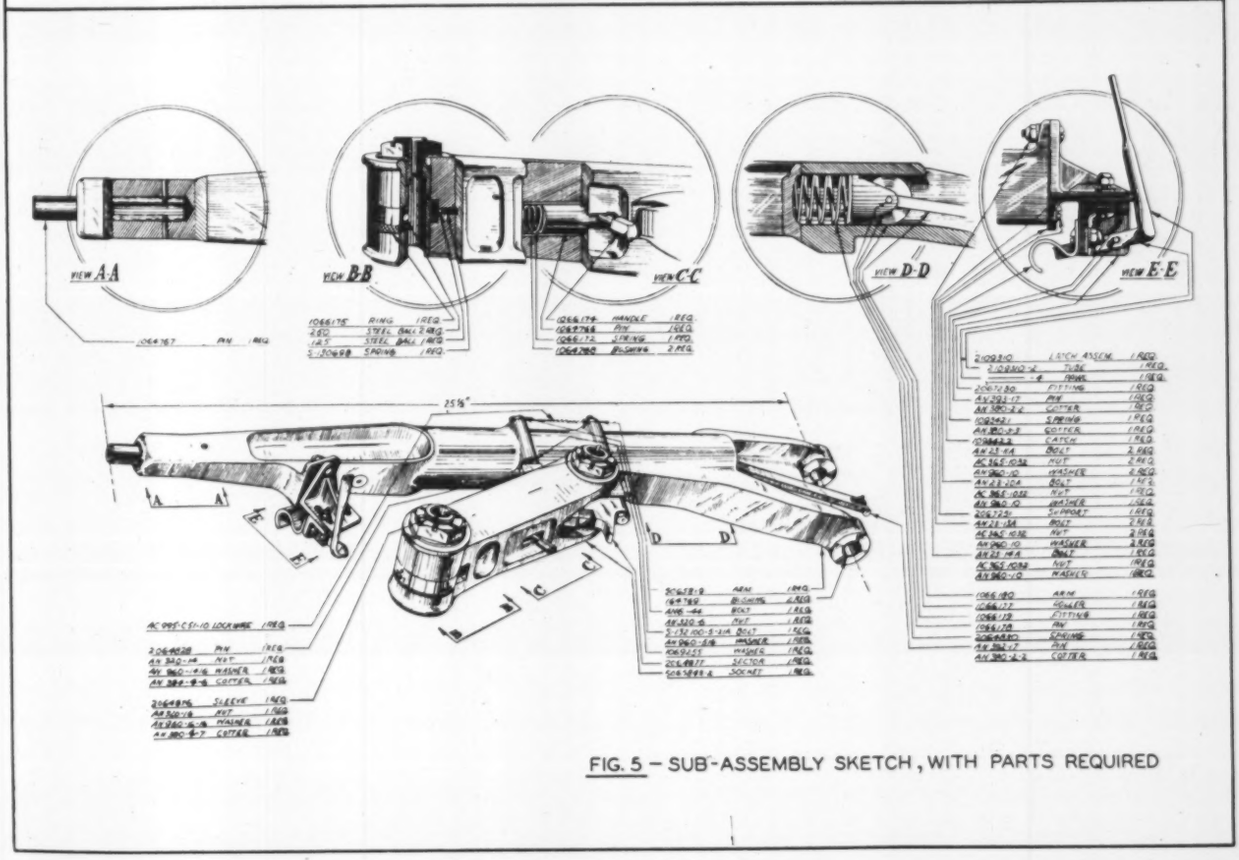


FIG. 5 – SUB-ASSEMBLY SKETCH, WITH PARTS REQUIRED

trols) concurrently with the engineering layouts to enable all concerned to obtain a clear and concise picture of each installation as assembled in the ship. These drawings are used by the engineering groups concerned, by the handbooks group for instruction manuals, the Material Division for ordering the shop coordinating supervisors for studying assembly-line breakdown, and, generally, throughout the factory for instructional purposes.

POSITION BREAKDOWN AND JOB TICKET SKETCHES

Position breakdown drawings, see Fig. 3, illustrating the progressive installation work accomplished at each position on the assembly line, are made in consultation with the coordinating supervisors, development men, and estimators concerned. (Floor positions on the assembly line are numbered in a typical example from 1 to 29. No. 1 is the position of the finished plane, and No. 29 is the first position following the fabrication jigs.) These drawings are designed to give an instant perspective picture of the work to be done in each section of the fuselage (e.g., Section 21, pilot's compartment above the floor; Section 22, below the floor; Section 23, first bomb bay) together with instructions on how to accomplish it in the most economical manner; they furnish lists of parts required and the necessary tools to complete the job, thus eliminating the tedious reference to large and unwieldy blueprints. Copies of these position breakdown sketches are issued for each section of every position on the assembly line for the use of the leadmen and mechanics concerned. They are also issued to Production Planning, Estimating, Inspection, the assembly-line stock room.

Job ticket sketches, Fig. 4, are made to break down in still greater detail the work to be done in each position on the assembly line. They are actually a "one-man, elapsed-time, job ticket." In the case of an assembly line, which will move every two hours, an illustrated job ticket is made for each man. It covers the work to be done by him in a two-hour period and gives him a list of parts and tools necessary to complete the job. Copies are issued to Production Planning, where they are used as a basis for the routing of all subassemblies, material, and parts to the assembly-line stock rooms; to the Time Standards Department; to the Inspection Department, to be used to plan individual inspector's work in unison with the assembly line; and to the assembly-line stock room as a guide for the final issuance of parts to the correct position in the assembly line.

SUBASSEMBLY SKETCHES

Subassembly drawings, Fig. 5, are made in consultation with the Production Planning Department for use as an illustrated guide for the bench assembly of subassemblies; they provide a complete list of parts and necessary instructions for each job.

PHOTOGRAPHS

Whenever a prototype airplane is available, a system of photographic illustration of installation and assembly operations is used to excellent advantage, particularly at the El Segundo Division of the Douglas Aircraft Co., where this system has been developed. Photographs such as Fig. 6 are adopted in lieu of drawings when the printed or lettered information accompanying the picture is not too great and when cutaway or exploded views are not required for clarity.

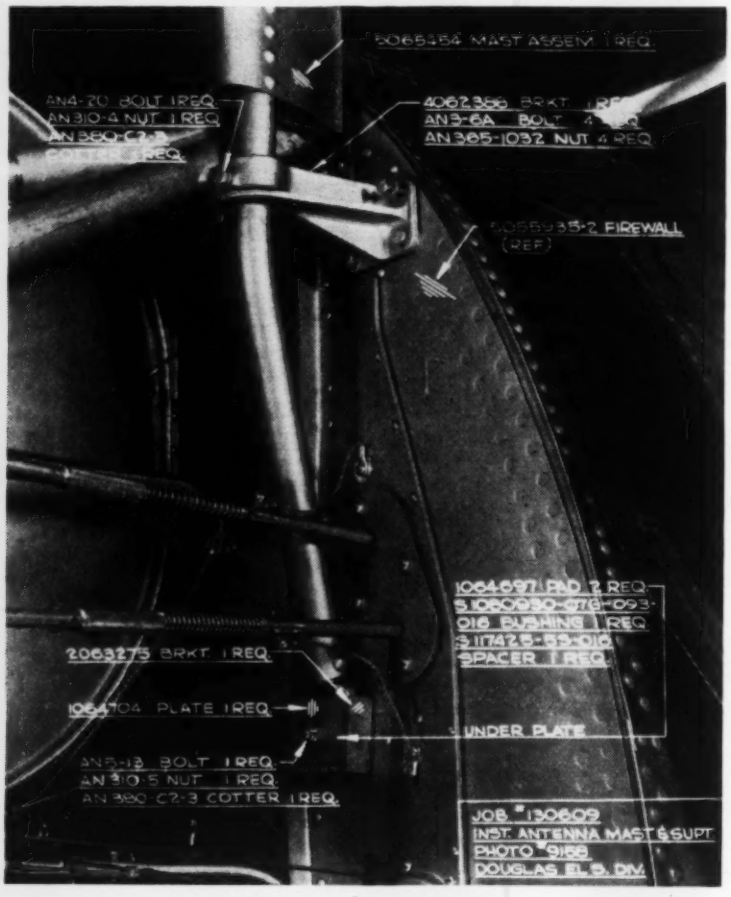


FIG. 6 INSTALLATION PHOTOGRAPH OF ANTENNA MAST AND SUPPORTS
(Showing mast as finally installed and giving parts required for installation.)

ECONOMICS OF DEFENSE[1]

By DONALD S. TUCKER

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

WITHIN recent months three excellent works on the economics of war or defense have been published. The first[2] of these is narrower in scope than the others. It is concerned only with financing the war; and, among the various possible methods of financing war expenditures, this book is concerned chiefly with only one. It is nevertheless a work of great merit.

The author of this first book, J. M. Keynes, advocates heavy taxation; but his real contribution is a suggestion for making war borrowing more effective. He calls his plan "deferred pay." Under this plan large sums would be collected weekly from all workers whose incomes exceed $25 a week. Part of these collections would be ordinary taxes; the remainder would be devoted to compulsory purchases of government bonds.

"DEFERRED PAY" PLAN

To some economists the chief interest of this plan lies in the possibility of diminishing thereby the violence of postwar business recession. In recessions businessmen liquidate their assets. This process provides them with money which they need for the payment of current debts. Banks and other creditors acquire thus during business recessions much money that could thereupon be used by these creditors for the purchase of other securities. Business liquidation creates also unemployment. In periods of liquidation and business recession many workers, because they are unemployed, would have good reason to liquidate their claims for deferred pay. Sale of bonds to creditor institutions would then permit the transfer to workers of money that they in turn could use for consumption purposes. In the postwar period such living on principal by workers would help to sustain purchases and business volume. The severity of postwar business recession might be thus diminished. In order that a nation may receive maximum benefit from this program, claims for deferred pay should also be made substantially nontransferable until hostilities end and large-scale government borrowing ceases.

To Mr. Keynes the primary value of his plan lies, however, in its emotional appeal. People will submit to larger exactions if they feel that they are getting something in return. Because Mr. Keynes has written his book in a clear and simple style, many people who have no interest in his particular proposal will nevertheless find his book of value to them. Mr. Keynes recognizes also the danger of price inflation that is inherent in excessive reliance on voluntary saving. His chapter analyzing the magnitude of the rise in prices that is likely to occur under given conditions is of especial value. Because this author's interest is so largely centered on the behavior of commodity prices, his work could well have been entitled "How to Pay for the War Without Causing Inflation."

Our second[3] work on the economics of defense is written by an American. It is in form a text of collegiate grade. It is also the most recent and most comprehensive of the three books mentioned here. Its style is clear and its arrangement good. Though its length (301 pages) is short for a college text, this book is inevitably the bulkiest of the three here under review. For this reason and because clarity rather than interest is the prime requisite of a good text, this excellent work also will receive only brief description here.

The techniques of economic control during war are fairly numerous. Taxation, rationing, and priorities are merely the more conspicuous. Each of our three works inevitably mentions many; but Mr. Keynes describes techniques only as they affect finance, and the book next to be described is interested chiefly in the reasons why they are necessary and in the area of the field most appropriate to each technique. For those who require greater detail with respect to the methods of control, this book by Mr. Menderhausen will probably be the most useful.

Prof. A. C. Pigou is an English economist of high standing. Some of his earlier works have been difficult reading even for professional economists. It is a pleasant surprise, therefore, to discover that his latest publication[4] is written in a style so limpid that any high-school student could understand it. One criticism may, however, be leveled at this work. Its style is so persuasive that some unwary readers may feel that what he says is only common sense, and that no book is necessary to tell us things so obvious. Those familiar with the techniques used and the ideas current in previous wars will recognize, however, the extent of the progress recorded here.

POLITICAL ECONOMY OF WAR

Professor Pigou's volume is so small that it fits comfortably into a coat pocket. Its division into sixteen short chapters adapts it well to perusal in sections by those whose reading time may be interrupted; and perusal by sections is strongly recommended here. The first two chapters are introductory; but each subsequent chapter contains material which the reader may well wish to think over for a little while before progressing to the next problem. All may find it worth while also to read first his one-page epilogue. Presentation of Professor Pigou's argument is of course impossible here; but a few of his conclusions may nevertheless be summarized.

The resources available for war consist of the nation's productive powers—its population and its material resources. These produce the income that must be diverted into military use. The real war fund arises therefore from (1) augmented production, (2) diminished consumption, (3) reduced investment in new capital goods, and (4) depletion of existing capital. The magnitude of the first depends on the amount of unemployment and leisure existing in the business system at the outbreak of hostilities. For the United Kingdom Professor Pigou estimates that an amount equal to 20 per cent of the prewar national income could be added and made available for war. Because the amounts available from the second and third sources are also large, Professor Pigou estimates that an amount equal to half the prewar income or five twelfths of the war income is in the United Kingdom available for military purposes. In 1918, he points out, about 2500 millions out of 2700 million

[1] One of a series of reviews of current economic literature affecting engineering, prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Opinions expressed are those of the reviewer.

[2] "How to Pay for the War," by John Maynard Keynes, Macmillan and Co., Limited, London, 1940.

[3] "The Economics of War," by H. Menderhausen, Prentice-Hall, Inc., New York, N. Y., 1940.

[4] "The Political Economy of War," by A. C. Pigou, The Macmillan Company, New York, N. Y., 1941.

pounds of government expense went into the war effort. This 2500 million pounds should be compared with a national income of about 5500 million, so that even in the last war military expenditures approximated half of the national income.

Depletion of capital may supplement income; but such depletion can be used only once. Depletion of material resources takes many forms. Inventories of merchandise may be reduced. Investments owned by nationals may be sold to foreigners. Loans may be negotiated abroad. The fixed assets of business may also fail to be maintained adequately; but this last-named source is less significant because such assets may be needed for the current effort. Current maintenance may therefore be imperative. Human capital also may be depleted if children fail to complete their schooling or if adults are worn out by sustained efforts at high intensity. If Professor Pigou could be said to display any bias, it is toward winning the war with as little depletion of capital as possible; but for the most part his discussion runs simply in terms of what is necessary in order to maintain morale and to win the war.

REAL COSTS OF WAR AND MONEY COSTS

Contrast between the real costs of war and its money costs is significant. If men and material are devoted to building something that is not useful, this is a real waste of resources. If, however, a government wastes an equal amount of money in overpaying contractors or workers, such overpayment is a mere transfer of rights within the nation. Subsequent debt payment by the government will transfer property from taxpayers to bond holders; but transfers among nationals do not alter the magnitude of the resources available within the nation for war efforts or for subsequent peacetime production. Waste, therefore, is of two kinds. Consumption of resources involves more than a mere transfer of money or rights. Waste of both kinds should be prevented; but waste of the first type is serious.

Citizens who curtail expenses in order to pay taxes or to buy bonds must choose which economies to effect. Economies in the amount of personal service demanded are necessary, and choice among these is easier because alternative uses are more obvious. Doctors, men with mechanical skill, and able-bodied young men are highly useful to a nation in wartime; but old people, violinists, and skilled gardeners are of relatively little value in a war effort. To dismiss a young chauffeur may therefore be a patriotic act; to dismiss an elderly nursemaid may operate only to increase some government burden. In selecting economies a patriotic citizen should therefore consider the alternative use which a nation can make of the factor released. Under some conditions economy in the use of oranges might be positively injurious; economy in the purchase of kitchen utensils might simultaneously be vitally needed.

Taxes and loans are necessary in order to meet government expenses. They are necessary also in order to deprive citizens of purchasing power which might otherwise be used in competition with government buying. Productive power must be transferred from civilian purposes to military use. Whether this transfer should be achieved through taxation or by borrowing is not the central problem. Both are necessary. The proper scope of each of these devices is therefore examined in thought-provoking manner, and a subsequent chapter discusses the technique of loans. Though many devices are approved, Professor Pigou concludes that the offer of high rates of interest on government bonds is unwise.

Goods may be purchased by negotiation or commandeered through the use of sovereign power. The railway system was thus commandeered in 1914 and again in 1939. Ships also have been requisitioned. With raw materials and consumption goods similar results can be attained if the government appoints itself the sole dealer. The advantage of commandeering is not that goods are thus diverted to government use; nor does it lie in the price which a government pays. The real advantage of commandeering lies in the fact that the transition from peacetime production to war purposes can by this means be expedited.

Financing by bank credits, the rationing of consumers, priorities, bounties, and the control of foreign trade and foreign investment each are given a chapter. Among these only the discussion of bounties can be mentioned here.

Canceling bounties differ in effect from normal bounties. Uses of the former are examined with approval. If a government limits the price of some good to a fixed maximum, businessmen will produce only such portion of the potential output as can be produced at a cost no greater than this maximum price. It may be desirable that the maximum price of some good should not exceed its prewar level. Only the prewar output would therefore be forthcoming. If more of this product is needed in wartime, higher-cost sources must be employed. Bounties may therefore be offered. Whether the bounty should be offered to all or offered only to high-cost producers depends in part on the conditions of supply. This problem has received little attention in America.

Because English experience with the necessities of defense has been greater than ours, it should perhaps not be surprising to discover from Professor Pigou's illustrations that economic controls in the United Kingdom have been more systematic and complete than is generally appreciated here. Because one Englishman at least has thought out and stated clearly the stark necessities engendering these controls, we have here a book more stimulating than mere lucid description. Because this reviewer, however, has emphasized the notable simplicity with which Professor Pigou has stated complex issues, one warning must regretfully be added. Problems of economic control are never truly simple.

Gerald Young

TECHNICAL TEDIUM *or* OTHERWISE

By R. W. CRUM

DIRECTOR, HIGHWAY RESEARCH BOARD, WASHINGTON, D. C.

AT LAST your time has come; after hours of waiting through the interminable and boring speeches of your fellow conferees the chairman is about to call upon you. He announces your paper; you rise and, accompanied by a scattering of perfunctory applause, walk briskly to the platform, only stumbling on the top step and getting your feet tangled in the wires strewn around the floor for the loud-speaker apparatus.

"Mr. Chairman, ladies, and gentlemen," you say, and reach in your inside coat pocket for the paper. Consternation reigns for a moment when you find it isn't there, but you haven't quite lost all of your presence of mind yet and remember that you put it in your left-hand outside coat pocket. Fishing it out you are ready to go ahead after first disburdening yourself of the few ill-chosen introductory words that you[1] have been mulling over the last hour and a half.

Your labored joke doesn't get much of a laugh but you are too flustered to bother about that. Grasping your bulky manuscript firmly but shakily in both hands and carefully avoiding the "mike," if there be one, you start to read. After reading one page you are somewhat appalled by the magnitude of the remaining task. You wonder momentarily if you are going to be able to get through in the allotted twenty minutes. But you haven't time to worry about that now and anyway time alone will tell. Gluing your eyes to the page you proceed. About this time some ill-mannered person in the rear of the room calls "louder." Rather resentfully you raise your voice for a few lines but you can't think of that and keep your place at the same time so your voice soon fades down to your usual tone and thenceforward you pay no attention to such unwarranted distractions.

By this time you have recovered some of your self-confidence and most of the shakiness is gone and you are forging ahead full steam. But you don't dare glance at the audience or it will return and you will lose your place. On and on you go without thought of time. By and by you become aware that the chairman is trying to convey some sort of signal to you, but you can't take on his troubles too, and you keep on reading till you realize that you have come to that welcome period when you can show the pictures.

Saying, "I have some lantern slides that I would like to show if there is time," you start a search for the push button that will signal the operator, finding it, after some confusion, grasped firmly in your right hand.

The first slide comes on and turning your back to the audience you rather confidentially tell the screen what the picture is about. This takes some time as it is a complicated table[2] with lots of data. This part of the speech doesn't take over a half hour as there are only about a dozen of the slides crammed with tabulated data and intricate curves. In doing this you repeat practically everything you read before the picture came on.

As the lights return you notice that the chairman is about to have apoplexy and there is a red light shining on the reading desk in front of you, but the whole point will be lost unless you read your conclusions and so you struggle on manfully to the bitter end.

At last there is no more to read. You say "I thank you" and stagger from the platform with the beginning of a mild inner glow that says to you "well done." This feeling is heightened by the applause which is louder this time, indicating that the audience's feeling of relief that you are through is slightly greater than its courtesy in giving you a hand when you started. To tell the truth, no one has listened for the last 45 minutes.

The chairman is now saying, "I am sorry that on account of the fact that we are way behind our schedule it will be necessary to defer the discussion of this interesting paper and proceed to the next item on the program."

You think, resentfully, that if the speakers before you hadn't taken so much time there might have been some interesting discussion of your absorbing topic. But you are too overwhelmed with relief at having the thing done to cherish that feeling long and settle down on the end of your spine to enjoy the next paper in a rather comatose condition.

But instead of being soothed by a gentle flow of monotone as you expect, something seems to be happening; your lethargy is being dispelled; the man on the platform is talking in such a way that you are becoming interested in spite of yourself. He is reading from a manuscript but from the way he is holding it you can tell it isn't very long. And he seems to know what he is saying so well that he can look up and actually talk to the audience most of the time.

It doesn't take him very long to tell what the paper is about and why and then he jumps right over the tedious details of what he did which took so much time in your paper and goes on to tell what he found out. Soon he comes to a place where some illustration is indicated. Without pausing in his stride he signals the operator and a slide comes on the screen; just a simple little table that anyone can grasp at a glance but full of significance. Glancing over his shoulder to make sure the picture is the right one, the speaker describes it quickly and goes on to the next thought in his paper. Presently he comes to the next slide. This time it is a diagram; just a single curve, but illustrating a telling point forcefully and without loss of time.

Well, time has been getting on and the chairman even in this case signals the speaker that his time is about up. Strangely, this doesn't seem to disconcert him; he just goes for the last sheet of the manuscript, reads it quickly and makes a graceful exit. Too good to be true—for a burst of appreciative applause wakes you up and you realize that at least part of this remarkable performance has been the figment of a dream, but the man has done a good job and got through almost on time.

Reprinted with permission and in the interests of better technical meetings, from the Proceedings of the American Concrete Institute, vol. 37, April, 1941.

[1] Any resemblance of the characters to any persons living or dead is entirely coincidental. The striking likeness of the first one to appear to the author of this paper is purely imaginary.

[2] The table was shown on the screen at this juncture—one of those tables so crowded with figures that its significant data (if any) dissolved into the all-over pattern of tight-woven homespun.

Maybe he took the secretary's letter of instructions seriously.

Musing on this while sticking out the rest of the program you think, "I wish I could present a paper like that" and later, being a person reasonably quick on the intake and still having plenty of self-confidence, you say to yourself, says you, "By heck, I can do a job like that." And so being a confirmed convention hound and a man of experience and ideas, besides having opportunities to write technical papers, you make yourself over into a forceful and interesting speaker by means of a few simple principles based upon your illuminating flash of insight while drowsing through a dreary session.

1 You realize that most technical papers have to be long enough to cover the subject thoroughly with supporting data to satisfy the studious reader who will ultimately use your material, but you also realize that there is no need to present all this orally and that no one would get it even if you did. No one can get the good out of a technical paper by reading it just once. Many passages must be read and reread, and reread and studied, so why should you expect anyone to grasp it all instantly while you read it to him. Better just read him the significant parts that he can assimilate as you go along.

2 It is apparent therefore that the first thing to do is to prepare a condensed version of the paper that can be read in the allotted time. Twenty minutes is about right, although some gifted persons can hold an audience with a dry subject for thirty.

In this version, tell what you did and why you did it and then jump right over the dreary details of how you did it and tell about what you found out that is new and interesting.

3 Having written the condensed version, read it aloud for timing. Then rewrite it so that the time will just be nicely filled. Then rehearse it—to your wife, or secretary, or the mirror—until you can deliver it with some degree of animation and direct appeal to the audience. (It sometimes helps to pick out someone who looks as if he agrees with you and aim many of your remarks at him. His nods will spur you on, or else pick out a dumb-looking one and see if you can wake him up.)

4 But let's not forget the slides. If well done they can add greatly to the quick comprehension of a technical talk. Just remember to express only one idea on a slide and make it so simple that about all you need to do is name it. It is best to use the slides to illustrate points as you go along. If left to be shown all together at the end there is a great tendency to waste time repeating what has already been said.

5 Sometimes you do miscalculate and the chairman calls time on you before you are quite through. Why not provide in advance for this contingency and if it arrives, just turn to the closing statement you have already prepared, read it, and stop.

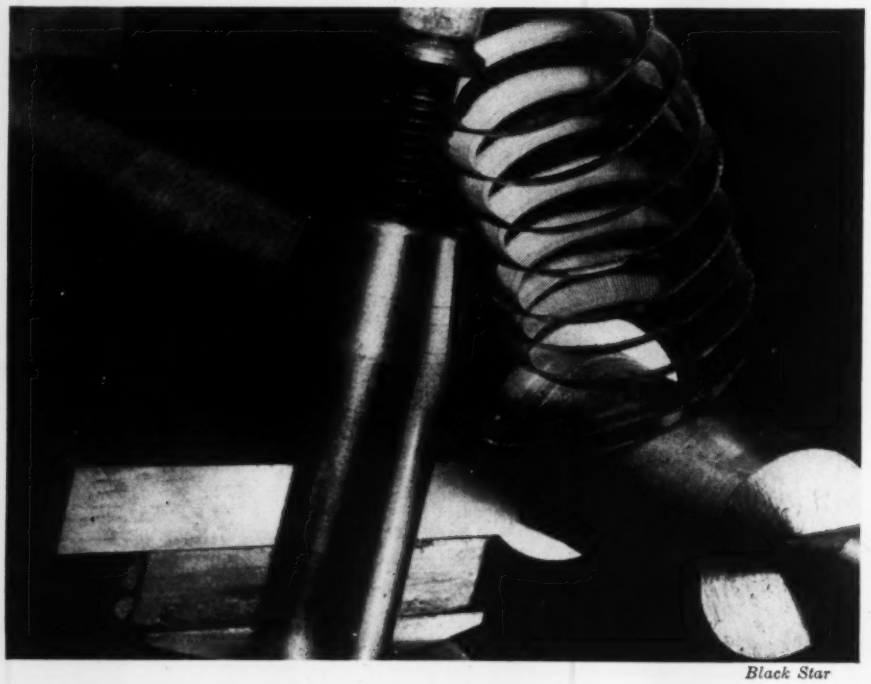
6 After you have prepared and delivered a few papers in this way you will probably discover for yourself that there is an even better way. Go ahead and write the short version, then write an outline of it, then memorize the outline, and soak yourself in your subject till you don't need a manuscript. Just talk and follow the outline in the back of your head. Of course it is a good idea to have a copy of the outline on small cards in your pocket in case of emergency. You are not likely to need it but if you do, it will save the day. Doing it this way it is also easy to go too long and bring the chairman's warning down on you, so have that prepared closure all ready to grab and read if you haven't had time to memorize it.

7 This is not intended for a discourse on technical writing, but one principle should be mentioned that is of particular importance in preparing a short paper for oral presentation.

Write simply, using short common-usage words and as few of them as possible.

For instance, to say: "When concrete is being placed during cold weather and the air temperatures may be expected to drop below 35 degrees Fahrenheit, a sufficient supply of straw, hay, grass, or other suitable blanketing material shall be provided along the line of the work and any time when the air temperature is expected to reach the freezing point during the day or night, the material so provided shall be spread over the pavement to a sufficient depth to prevent freezing of the concrete before it has thoroughly hardened," may be perfectly good specification writing, but if you want to make the point in a speech why not say: "During freezing weather freshly laid concrete pavement should be protected by a suitable insulating layer."

On reading this thing over, it doesn't seem so difficult; I don't think one needs to be an expert to follow these rules. I think I will try it myself some day.



Black Star

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

University and Industry

ENGINEERING

THROUGH the columns of *Engineering* (May 2, 1941) come some hitherto unnoted comments by Ralph E. Flanders, past-president A.S.M.E., contained in an address "The University and Industry" delivered on the installation of Dr. Howard L. Bevis as president of The Ohio State University.

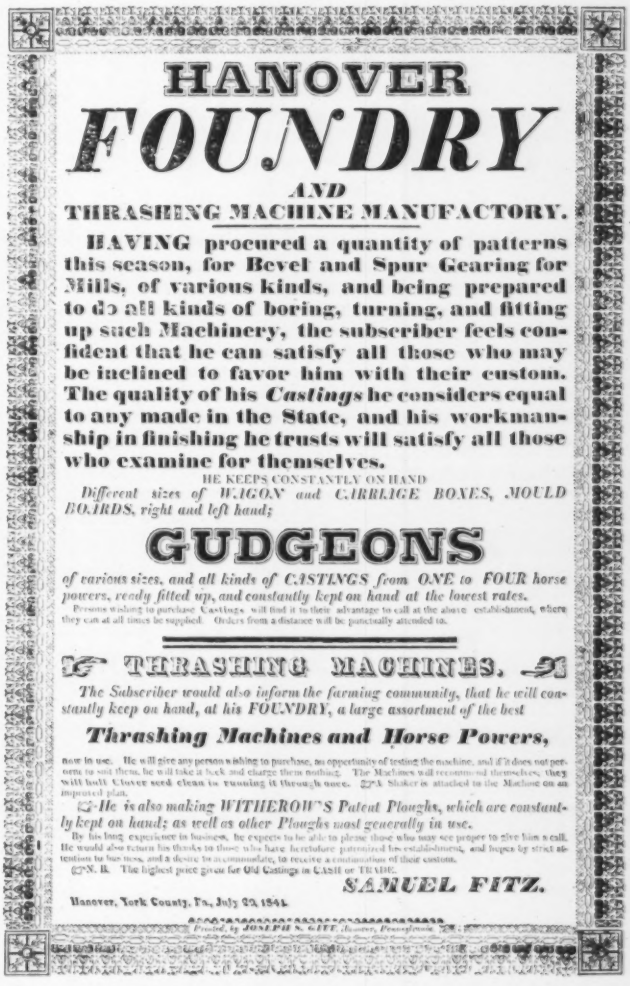
Mr. Flanders suggested a tabulation of functions of practicing engineers (maintenance, operating and processing, production methods, executive functions, designing, consulting, and research) which, he said, were "not given in the order of the monetary rewards involved," but roughly "in ascending order of the rigor of engineering training required."

These seven functions Mr. Flanders then segregated into three groups. The first comprises maintenance, operating and processing, and production methods, which "may be said to constitute the group of technicians." The second group is made up of the executive functions. The third group (the designers, the consulting engineers, and the research men), he said, "all require the most rigorous training in fundamentals, and it is highly doubtful whether elaborate courses on the details of present practice are anywhere near as valuable as this thorough grounding." These three groups of functions suggest to Mr. Flanders three types of curricula which may or may not be carried on in the same school.

Turning to the educational problem considered from the standpoint of business as a whole, Mr. Flanders made the following comments:

The process of education should help, rather than hinder, the adjustment of the student to industrial life. The student should learn to work with people. He should understand that, while successful cooperative effort may and should result in advantage to the individual, that advantage will not ordinarily accrue to him who fixes his eye too intently on the personal advantage rather than on the cooperative achievement. The university will need to learn, particularly in its sociological divisions, that men are not alike, that they do not have the same emotions, the same driving forces, the same problems. Perhaps there is nothing more astonishing to the college graduate who goes out into industry than the discovery that by far the greater percentage of mankind is happiest in a routine job. Those who analyze and systematize human activity into textbook form would not be happy under routine conditions, and, therefore, find difficulty in adjusting their minds to the concept that others may differ so greatly from themselves.

A complementary concept must be established in the mind of the young man of ability and training who goes out into industry. That concept is that, with the group which seeks responsibility rather than routine, that responsibility is very deep and widespread. That responsibility is for the well-being and security of that major part of humanity which is unwilling or unable to take responsibility. If the advantages of security and well-being are to be available to the mass of mankind, the exceptional man must be educated to the idea of venture, risk, and responsibility. It is not the least serious of the new tendencies of our time that the idea of security, as against enterprise, has been injected into the bloodstream of industrial management and industrial financing. Unless this poison can be eliminated, there will be no well-being and no security for the mass of the workers—no solvency nor permanent beneficence in the government which is sustained by their votes. If we are to be safe, the next generation of the leaders of society now being trained within these walls must be familiarized with business enterprise, business risk, even while



HANOVER
FOUNDRY
AND
THRASHING MACHINE MANUFACTORY.

HAVING procured a quantity of patterns this season, for Bevel and Spur Gearing for Mills, of various kinds, and being prepared to do all kinds of boring, turning, and fitting up such Machinery, the subscriber feels confident that he can satisfy all those who may be inclined to favor him with their custom. The quality of his *Castings* he considers equal to any made in the State, and his workmanship in finishing he trusts will satisfy all those who examine for themselves.

HE KEEPS CONSTANTLY ON HAND
Different sizes of WAGON and CARRIAGE BOXES, MOULD BOARDS, right and left hand;

GUDGEONS

of various sizes, and all kinds of CASTINGS from ONE to FOUR horse powers, ready fitted up, and constantly kept on hand at the lowest rates.

Persons wishing to purchase Castings will find it to their advantage to call at the above establishment, where they can at all times be supplied. Orders from a distance will be punctually attended to.

THRASHING MACHINES.

The Subscriber would also inform the farming community, that he will constantly keep on hand, at his FOUNDRY, a large assortment of the best

Thrashing Machines and Horse Powers,

now in use. He will give any person wishing to purchase, an opportunity of testing the machine, and if it does not perform to suit them, he will take it back and charge them nothing. The Machines will recommend themselves, they will both Clover seed clean in running it through once. ☞A Shaker is attached to the Machine on an improved plan.

☞*He is also making WITHEROW'S Patent Ploughs, which are constantly kept on hand; as well as other Ploughs most generally in use.*

By his long experience in business, he expects to be able to please those who may see proper to give him a call. He would also return his thanks to those who have heretofore patronized his establishment, and hopes by strict attention to business, and a desire to accommodate, to receive a continuation of their custom.

☞N. B. The highest price given for Old Castings in CASH or TRADE.

SAMUEL FITZ.

Hanover, York County, Pa., July 29, 1844.

Printed by JOSEPH S. GITT, Hanover, Pennsylvania.

FACSIMILE OF 100-YEAR-OLD POSTER OF HANOVER FOUNDRY AND THRASHING MACHINE MANUFACTORY, HANOVER, PA., ISSUED BY SAMUEL FITZ AND PRESENTED TO THE ENGINEERING SOCIETIES LIBRARY BY HIS GRANDSON, ERWIN M. FITZ, MEMBER A.S.M.E.

discharging their responsibilities of conserving the well-being of the larger proportion of routine workers dependent upon them.

The sum total of the problems and opportunities found in the general subject of the university and industry forms a composite problem of very great dimensions. Yet the problem itself is something much greater than the sum of the parts we are discussing here today. Over and above the parts exists the general problem of discovering how the truly educated man can be effective in guiding the destinies of a democracy. We can plainly see how this university can improve agriculture, how it can train men for the professions, how it can serve industry, how it can develop the social sciences, and how it can prepare its graduates for humane living. What it is not so easy to see is how these separate but interrelated activities can be focused on the over-all control of our national destiny for the benefit of our fellow citizens and ourselves.

The role of the scholar with a liberal or technical education, or a combination of the two, is quite clear in the new types of government arising elsewhere in the world. He no longer exists as a free agent. His attainments are directed in detail to serve the inferior purposes of a society organized on superior force. The role of the educated man in a modern democracy is by no means so clear. The chasm between knowledge and good will, on the one hand, and political accomplishment, on the other, is deep and wide. Meanwhile, our destinies are guided more and more directly, over a larger and larger area, by forces acting in the political field. This is the great undertaking—an effective relation between the university and the sum total of the secular activities of our nation. This is the problem which must be solved, and the manner of whose solution is as yet by no means clear. We do not believe that it cannot be solved. We do know that its solution will require the full devotion of every one of us.

Welding in Wartime

ENGINEERING

A SPEECH by H. J. Gough, director of scientific research at the Ministry of Supply, delivered in London on April 23 at a luncheon of the Institute of Welding, is reported in *Engineering* for May 2, 1941. Dr. Gough mentioned investigations into the strength and behavior of steel framework with rigid joints, and his comments are reported as follows:

It has been shown that the load-carrying capacity of such rigid steel frames exceeds that of a similar structure with flexible joints by as much as 30 per cent . . . . In wartime it is especially significant that such a rigid frame, or even one possessing continuity in the framework, will resist the effects of blast when a structure built to ordinary designs will collapse.

Dr. Gough instanced the use of welding in the construction of portable hangars, military bridging equipment, light armored cars, and of bombs and shells, in the endeavor to save weight. By the employment of welding instead of riveting in the construction of an antiaircraft-gun platform, for example, there had been a saving of 19 per cent in weight and of 63 per cent in man-hours. A similar change-over for a field-carriage assembly reduced the production cost per unit from 269*l* to 60*l*. This was mostly due to a saving in machining time. The aggregate saving was 2,000,000*l*.

While these examples relate to actual achievements, there are several important developments which are worthy of close consideration. It has been shown, for instance, that a saving of weight of as much as 20 per cent can be effected by using fabricated construction in shipbuilding. It is estimated that about 50 per cent of the whole output of welding materials is already being used for this purpose, but it is obviously worth while to consider whether this figure could not be improved. Even more interesting are the advances in technique which have made practicable the welding of armor plate for fighting vehicles, as this will lead to a reduction in deadweight which can either be saved or employed for other purpose. Generally speaking, too, it is worth while making special efforts, by the more extended use of welding, to relieve the machining capacity of the country and equally the load imposed on the drop-stamping machines and foundries. As is well known, substantial economies can be effected by welding together a number of component parts of suitable design to form a complete unit.

Dimensional Control

SAN FRANCISCO SECTION, A.S.M.E.

AT A symposium on production methods applicable to defense industries held on May 22, 1941, by the San Francisco Section of The American Society of Mechanical Engineers, Harold T. Avery, chief engineer, Marchant Calculating Machine Company, presented a paper entitled "Dimensional Control in the Manufacture of Small Machine Parts." After discussing the various types of punch-press dies and the work produced by them Mr. Avery goes on to explain the methods used for checking and control in the manufacture of die-made parts for calculating machines. On these stamped parts the tolerances allowed are generally plus or minus one or two thousandths of an inch.

The design drawings are mostly made to a scale five times the actual, and dimensions are practically all established from the drawings. Most of the close tolerances occur on curved cam surfaces and the like which are difficult to compute, and therefore direct work from careful layouts is the most satisfactory method. The same considerations that make it impracticable to use computations to determine the original outline of a part also make it practically impossible to check the majority of these outlines on the parts themselves by ordinary checking methods. Shadow-projection machines are therefore used for comparison, and except for occasional studies of working surfaces of gear teeth or the like which are made at a scale of sixty to one, all of this projection is done at a scale of twenty to one. This scale is small enough to permit most of the parts to be shown completely in a single projection and large enough so that departures from contours considerably less than the tolerance limits show up as variations of from a thirty second to a sixteenth of an inch, which can be readily detected.

As soon as the design of a part is completed it is carefully redrawn to a scale of twenty to one on special nonshrinkable drafting paper. A detail of the part showing numerical dimensions and tolerances is sent to the experimental shop along with a twenty-to-one drawing. If only one or two experimental parts are required, the experimental worker lays out the part by scribing on blue steel by means of a height gage and dividers and works the part out substantially to the scribed lines by band-sawing, drilling, filing, and similar methods. When the part is approximately to line, it is projected and checked against the twenty-to-one drawing. When projection shows the experimental part to be correct it is ready for trial in the experimental machine. If during the experimental stage minor changes from the initial design are found to be necessary, as is frequently the case, it is a simple matter to change the twenty-to-one drawing to correspond.

Following proof of the experimental machine, it is usually customary to construct a wave of three to five trial machines further to prove the new construction. Since this requires making several of each kind of part, temporary tools are necessary in order to produce economically the required number of parts. One method ordinarily employed, when the requirement is for from a half dozen up to several dozen parts, is that of nibbling. A thick hardened template corresponding to the outline of the part is made up, doweled to each piece of metal in turn, and fed through the nibbling machine. This machine consists of a rapidly reciprocating punch which does not rise high enough to clear the template on top of the workpiece. The nibbling punch has a smaller tenon extending downward from its cutting end which never rises clear of the metal being cut and therefore limits the feed between punch strokes to the difference in radii of the punch and the tenon. Thus by holding the edge of the template against the side of the punch and feeding around the template the piece is cut out. Groups of the nibbled pieces are then doweled between a pair of filing templates and the necessary parts of the outline are smoothed up exactly to dimension.

Of course the nibbling and filing templates are checked against the same twenty-to-one drawing when they are made.

If more than a few dozen parts are required in the development stage, it is better to make temporary dies instead of nibbling the parts. Punch and die of sheet tool steel and stripper plate are all cut to templates on a Keller automatic die-contouring machine. The stripper plate is bolted to the die to guide the punch plate and a part is blanked by sliding the assembly into a press and hitting it with the ram. If only a few hundred parts are required, it is much more economical to produce in this way than to go to a regularly mounted die.

Production dies are cut on the same contouring machine using heavier sections of tool steel. A little more material is left for hand fitting, and punch and die are mounted on die shoes equipped with guide pins. Round holes in dies such as those in pierce dies and the dowel holes in other dies are located to within 0.0001 in. by a Pratt & Whitney jig-boring machine.

When the part has passed into regular production the twenty-to-one drawings of all parts in the machine are kept on file so that production parts can be checked by projection at any time to determine whether there has been any departure from the desired dimensions. This method of projection checking eliminates the necessity of providing a great number of individual gages for checking the outlines of the many different parts, and greatly simplifies the whole system of dimensional control. Mr. Avery's paper concludes with a detailed explanation of the operation of automatic screw machines and the work they perform at the author's plant.

Direct Injection Vs. Carburetor

NATURE, JULY 26, 1941

REPLYING to the debate upon aircraft supply in the House of Commons, on July 10, the Minister of Aircraft Production, Lieut-Colonel Moore-Brabazon, mentioned that where the British aero-engine industry uses the carburetor, the Germans have adopted the fuel injection system. The use of direct fuel injection, as an alternative to the carburetor of spark-ignition aero engines, is put forward in some quarters as a cure for the many shortcomings of the carburetor engine, and, in particular, as a means of improved performance at altitude. The injection may be made either before the entry to the supercharger, into the induction manifold, or directly into the engine cylinders. The German systems inject direct into the cylinders, which, having regard to the all-round advantages of the three methods, is probably the best position.

The claims to superiority of the injection system as compared with the carburetor are as follows:

(1) No restriction is offered to the free "breathing" of the engine, because the pressure drop necessarily incurred at the venturi of the carburetor (and not recovered) is eliminated. This pressure drop is about 1 in. of mercury at ground level and increases with altitude if the air flow is constant, because of the fall in air density. It is only significant at altitudes above the "rated" or full-throttle height. If the venturi is made larger, so as to reduce the "throttling" at high altitudes, the pressure drop available for fuel metering may be inconveniently small at lower altitudes. Further, eliminating the carburetor gives a clearer entry for the air into the supercharger. The total effect, above the rated altitude, is to increase the height at which a given boost pressure, and therefore power output, is available, and hence to improve the ceiling of the aircraft. It should be noted, however, that the beneficial effect of fuel cooling, in increasing the pressure ratio of the supercharger, is lost, a factor tending to outweigh the gain conferred by reduced restriction to the airflow. The disadvantage of a low metering pressure can be eliminated by using a "blown" or pressure carburetor after the supercharger.

(2) The induction system is freed from the hazard of "refrigeration" icing, because the effect of evaporative fuel cooling is absent. This is a very real advantage as compared with the now obsolescent unheated carburetor, but carburetors are available which are immune from freezing trouble.

(3) There is superior fuel economy due to perfect distribution to individual cylinders. It should be noted that the air distribution is, however, unaffected. Comparative tests indicate that there is little difference in economy between the carburetor and the injection system, at least at normal air temperature. It is possible, however, that at high altitudes, when it is known that distribution becomes poor, the injection system may score. Alternatively, fuel of lower volatility may be used, although it is understood that fuel which is taken from German tanks indicates that no reduction in knock rating is being made.

(4) Freedom from inertia effects. This is a definite advantage during fighting maneuvering, but it applies only to the float-type carburetor. Pressure-injection carburetors are available which are equally unaffected either by altitude or by acceleration.

(5) Reduced risk of vapor lock at high altitudes, due to the absence of fuel pressure drops in the system and the accompanying risk of vapor evolution. The injection pumps themselves are susceptible to vapor and air in the fuel supply and the Germans fit deaerators to deal with this risk.

(6) The injection system would be essential for a two-stroke cycle engine in order to eliminate fuel waste during the scavenge period, unavoidable with a carburetor.

It appears that, on balance, the injection system, as compared with many present carburetors, has some slight but definite advantages. Against these must be set the extra complication of the fuel pump and nozzle, and the high standard of accuracy essential to their production and maintenance. This latter question is not without its importance under war conditions. The Junkers system comprises 1576 parts, 327 being different, and weighs 60 lb as compared with the Rolls Royce Merlin's 433 parts, 141 being different, and weighing 25 lb. There is also likely to be a definite limitation to the operating speed of the injection pump, whereas no such limitation applies to the carburetor.

Aluminum Fabrication

THE expansion of aircraft and aircraft-parts production, outside of regular aircraft companies, has led to a demand for information about aluminum alloys used in aircraft. Two new books are now available furnishing data needed to employ aluminum successfully.

"Aluminum in Aircraft" contains about fifty pages of general information on aluminum alloys and methods of fabricating, and another fifty pages of tables giving mechanical properties, standard sizes, and commercial tolerances.

"Forming Aluminum" gives information on drawing, spinning, and other methods used in fabrication.

Copies of either or both of these booklets will be sent upon request to Aluminum Company of America, Pittsburgh, Pa., or to the nearest sales office.

Thermal Conductivity of Wood

HEATING, PIPING, AND AIR CONDITIONING

A REPORT on heat-conductivity tests on wood is contained in the June, 1941, issue of *Heating, Piping, and Air Conditioning* in a paper by J. D. MacLean, senior engineer, Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, Madison, Wis. According to Mr. MacLean, some of the more significant variables affecting the rate of heat flow in wood are the following: (1) density of the wood; (2) moisture content of the wood; (3) direction of heat flow with respect to the grain; (4) kind, quantity, and distribution of extractives or chemical substances in the wood, such as gums, tannins, or oils; (5) relative density of springwood and summerwood; (6) proportion of springwood and summerwood in the timber; (7) defects, like checks, knots, and cross grain structure.

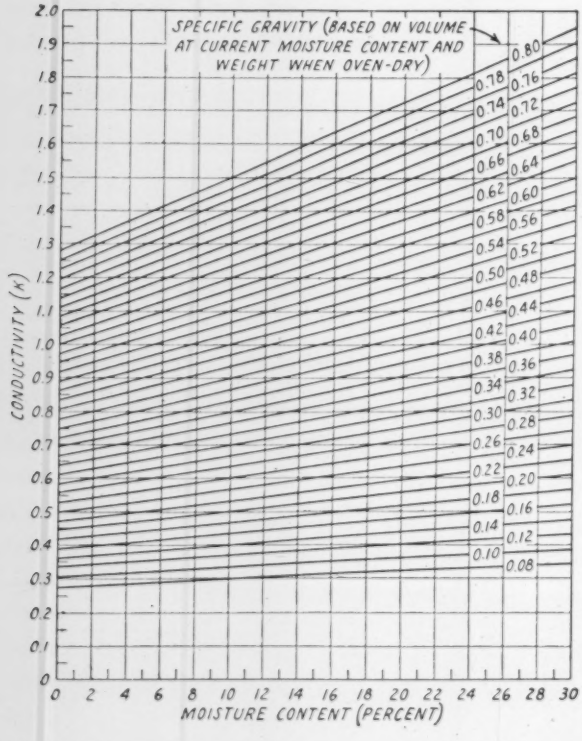


FIG. 1 RELATION BETWEEN COMPUTED CONDUCTIVITY, MOISTURE CONTENT, AND SPECIFIC GRAVITY AT CURRENT MOISTURE CONTENT

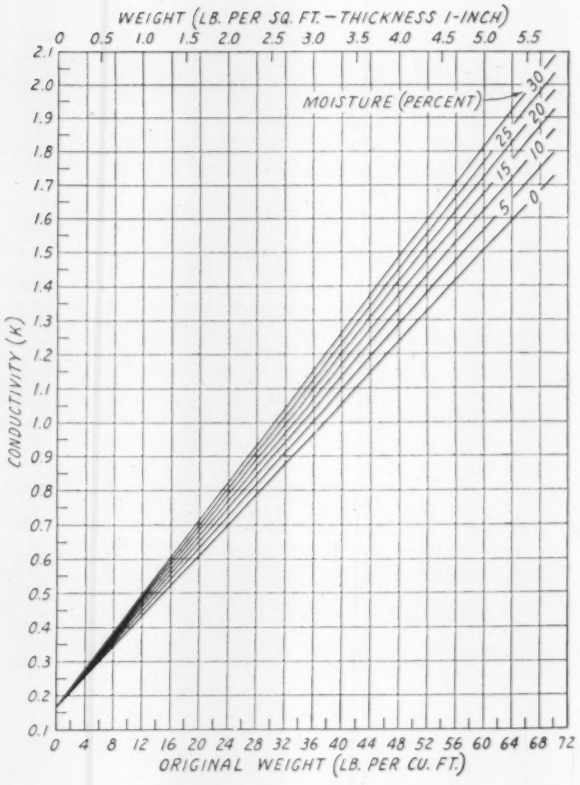


FIG. 2 RELATION BETWEEN COMPUTED CONDUCTIVITY AND ORIGINAL WEIGHT OF WOOD AT CURRENT MOISTURE CONTENT M

Most of the experiments were made with temperature differences of 40 to 60 F between the hot- and cold-plate surfaces. In some runs the conductivity was first determined with a temperature difference ranging between 40 and 60 F, and following this the hot-plate temperature was raised to give a temperature difference of from 80 to 90 F to investigate whether higher temperature differences would make any important change in the conductivity. In most of the runs the temperature difference between the two faces of the specimens was about 53 F and the average temperature of the specimens (average temperature of hot-plate and cold-plate surfaces) was about 85 F.

The values of thermal conductivity K determined in these tests are heat quantities in British thermal units that flow in one hour through one-inch thickness of material, one square foot in area, when the temperature difference between the two surfaces is one degree Fahrenheit, or

$$K = QX/(T_1 - T_2)A\theta$$

where

Q = quantity of heat, Btu
x = thickness of test panel, in.
T_1 = temperature of hot-plate side, deg F
T_2 = temperature of cold-plate side, deg F
A = area through which the measured heat passes, sq ft
θ = time, hr

The results of tests on oven-dry wood showed that the conductivity was in general directly proportional to the specific gravity, over the range for the woods tested. The equation of this relationship is

$$K = 1.39\,S + 0.165 \quad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

where S = specific gravity of the oven-dry wood.

TABLE 1 AVERAGE SPECIFIC GRAVITY OF VARIOUS SPECIES OF SOFTWOODS AND HARDWOODS

SPECIES	SPECIFIC GRAVITY BASED ON VOLUME WHEN GREEN AND WEIGHT WHEN OVEN DRY = *Sg*
HARDWOODS	
Ash, white (Fraxinus americana)	0.55
Basswood, American (Tilia glabra)	0.32
Beech, American (Fagus grandifolia)	0.56
Birch, yellow (Betula lutea)	0.55
Blackgum (Nyssa sylvatica)	0.46
Chestnut, American (Castanea dentata)	0.40
Elm, American (Ulmus americana)	0.46
Elm, rock (Ulmus thomasii)	0.57
Hackberry (Celtis occidentalis)	0.49
Hickory, mockernut (Hicoria alba)	0.64
Maple, silver (Acer saccharinum)	0.44
Maple, sugar (Acer saccharum)	0.56
Oak, red (commercial) (Quercus sp.)	0.56
Oak, white (commercial) (Quercus sp.)	0.59
Pecan (Hicoria pecan)	0.60
Sweetgum (Liquidambar styraciflua)	0.44
Sycamore, American	0.46
Tupelo, water (Nyssa aquatica)	0.46
Walnut, black (Juglans nigra)	0.51
Yellowpoplar (Liriodendron tulipifera)	0.38
SOFTWOODS	
Baldcypress (Taxodium distichum)	0.42
Douglas-fir, coast (Pseudotsuga taxifolia)	0.45
Fir, white (Abies sp.)	0.37
Hemlock, eastern (Tsuga canadensis)	0.38
Hemlock, western (Tsuga heterophylla)	0.38
Larch, western (Larix occidentalis)	0.48
Pine, eastern white (Pinus strobus)	0.34
Pine, jack (Pinus banksiana)	0.39
Pine, loblolly (Pinus taeda)	0.47
Pine, lodgepole (Pinus contorta)	0.38
Pine, longleaf (Pinus palustris)	0.54
Pine, ponderosa (Pinus ponderosa)	0.38
Pine, red (Pinus resinosa)	0.44
Pine, shortleaf (Pinus echinata)	0.46
Pine, slash (Pinus caribaea)	0.56
Pine, sugar (Pinus lambertiana)	0.35
Pine, western white (Pinus monticola)	0.36
Redcedar, eastern (Juniperus virginiana)	0.44
Redcedar, western (Thuja plicata)	0.31
Redwood (Sequoia sempervirens)	0.38
Spruce, Engelmann (Picea engelmannii)	0.31
Spruce, Sitka (Picea sitchensis)	0.37
Spruce, white (Picea glauca)	0.37
Tamarack (Larix laricina)	0.49
White-cedar, northern (Thuja occidentalis)	0.29

Data are also furnished on conductivities and moisture distribution for samples with moisture content varying all the way up to saturation. For the higher moisture contents the conductivity decreased with increase in time of test. This change would probably continue until a condition of moisture equilibrium was established for the differences in temperature between the two faces.

The results indicate that when the average moisture content was about that of air-seasoned wood, 15 per cent or less, there was usually no significant change in conductivity after 24 hours in test. In fact, data taken 5 or 6 hours after specimens having this range of moisture content were placed in test showed there was little change and often no change in conductivity from that found after test periods of 24 hours or more.

Since both the specific gravity and moisture content can be determined or estimated within reasonable limits for a given species and for particular conditions of service under which the wood is used, a formula for computing the approximate conductivity would be of particular assistance in questions relating to the insulating properties of different woods. An equation showing the relation of conductivity, specific gravity, and moisture content would make it possible to disregard species and to calculate, within reasonable limits, the conductivity of any wood without making conductivity tests.

The results of experiments discussed in the paper indicate that the following formulas serve to compute the conductivity closely enough for practical purposes:

$$K = S\,(1.39 + 0.028\,M) + 0.165 \quad [2]$$

for wood having varying amounts of moisture up to a little over the fiber-saturation point (values under 40 per cent).

$$K = S\,(1.39 + 0.038\,M) + 0.165 \quad [3]$$

for green wood having 40 per cent or more moisture. In these equations K = conductivity, S = specific gravity in oven-dry condition, and M = moisture content = $[(W - D)/D]\,100$, where W is the original weight and D is the weight after oven-drying.

Fig. 1 shows the relation of conductivity, moisture content, and specific gravity based on volume at current moisture content and oven-dry weight. The specific gravity

$$S = [W/(1 + 0.01\,M)]/W_w = 100\,W/(100 + M)W_w$$

where W is the original weight of a unit volume of the wood at moisture content M, and W_w is the weight of an equal volume of water: if W is in pounds per cubic foot, W_w is taken as 62.4 lb.

Fig. 2 shows the relation of weight of wood and conductivity for moisture-content intervals from 0 to 30 per cent. The ap-

proximate average moisture content must of course be known or assumed in order to use this chart. Fig. 3 shows the relation between computed conductivity and moisture content for woods having various values of specific gravity based on volume when green and weight when oven-dry.

The following example illustrates the use of Fig. 3. Assume

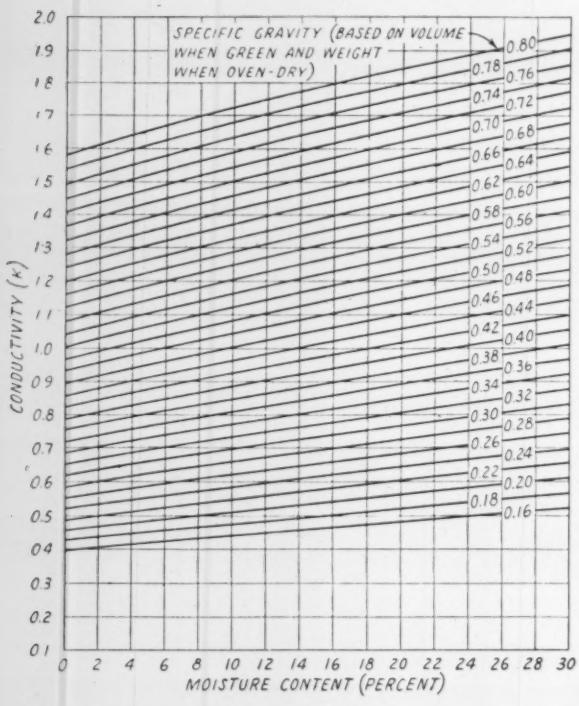


FIG. 3 RELATION BETWEEN COMPUTED CONDUCTIVITY AND MOISTURE CONTENT FOR WOODS HAVING VARIOUS VALUES OF SPECIFIC GRAVITY BASED ON VOLUME WHEN GREEN AND WEIGHT WHEN OVEN-DRY

it is desired to find approximately the average conductivity of loblolly pine at 15 per cent moisture. Table 1 shows the average specific gravity of this wood when green is 0.47. By following the vertical line for 15 per cent moisture to a point halfway between the lines for specific gravities of 0.46 and 0.48 the conductivity opposite this point (read on left-hand scale) is shown to be about 1.07.

Light Portable Fire Pumps

ENGINEERING

IN THE June 13, 1941, issue of *Engineering* there is published a description of the light wheelbarrow type of fire pump manufactured in Coventry, England. The manufacturers also make larger self-contained pumping units permanently mounted on trailers for towing behind vehicles, but this article describes the man-handled unit.

This appliance can be kept on a particular site and wheeled about to the required position on that site, or it can be loaded on to a carrying trailer and transported from site to site, being then unloaded and run into positions inaccessible to the trailer. This type of fire engine is shown in Fig. 4. The front end of the tubular frame is masked by the side of the trailer, but it is carried on two wheels with pneumatic tires, 10 in. in diameter, beyond which point it is prolonged into a pair of carrying handles. The unit, when removed from the trailer, can thus be either run where required wheelbarrow fashion, or carried by the handles at each end in the manner of a stretcher. This portability is a very useful asset, as the unit can be taken up or down steps, lifted over obstructions, and so forth, and can thus be taken to sources of water which a trailer might not be able to reach.

The unit can, of course, be loaded onto any type of vehicle if it is to be transported from site to site, with the hose, suction strainer, and other appurtenances, being handled separately. If the trailer shown in Fig. 4 is employed, this equipment is carried on it, there being provision for six 50-ft lengths of delivery hose, two 10-ft lengths of suction hose, suction strainer, and tools. The trailer is suspended on underslung semielliptical springs and has two detachable wheels with pneumatic tires, 18 in. in diameter. There is a connection for towing by a vehicle, and for this method of transport 8-in. mechanical brakes with automatic overrun devices are fitted. The brakes can be hand-operated for holding the trailer when stationary and three adjustable jacks are provided for support in this condition. For manual handling of the trailer two folding tow bars are fitted and two lengths of Manila drag rope.

The pumping unit is also fitted on a chassis with two large-sized wheels. This form is known as the "Wheelabout" and is not designed for towing behind a vehicle, but for handling by man power within comparatively small areas, as, for instance, on shipboard and in institutions.

The pumping unit apart from questions of transport is known as the F.S.M. model. Its delivery, with a vertical suction of 10 ft, at a pressure of 60 psi in the delivery, is 225 gpm, at 100 psi 155 gpm, and at 120 psi 130 gpm. If required for foam fire extinguishing, the unit will produce 1350 gal of foam per min when using three foam-making branch pipes.

The engine, which is of the petrol four-stroke cycle type with side valves, has four cylinders, 56 mm bore by 86 mm stroke, and develops 23 bhp at 3500 rpm. The Royal Automobile Club rating is 7.76 hp. The pump is of the firm's single-stage centrifugal type, with a 3-in. nominal suction inlet.

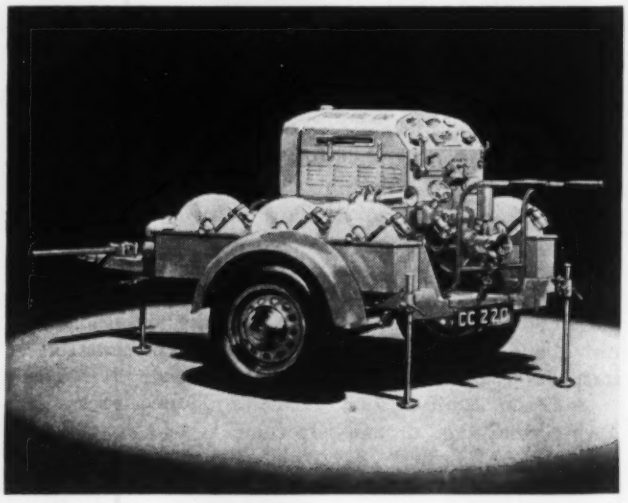


FIG. 4 PORTABLE WHEELBARROW-TYPE FIRE ENGINE LOADED ON TRAILER

The pump-priming device consists of means for passing the gases from the exhaust manifold of the engine through an ejector which will produce a vacuum of 24 in. of mercury in the suction line.

The article gives details of the engine construction and there are included sectional views of the engine, pump, and priming device.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Friction Torque in Ball and Roller Bearings

COMMENT BY THOMAS BARISH[1]

This paper[2] has very definite practical value for comparing bearing types and operating conditions. The small friction by itself rarely has any significance except in such special cases as instrument pivots, selsyn motors, and controllable propellers. However, the real value of the author's excellent data comes from the fact that the friction directly indicates the heat generated in the bearing and frequently determines the limits to its allowable operating conditions.

The author's objection to the use of coefficient of friction is difficult to understand in view of his statement that the friction torque is roughly proportionate to the load, which means more simply that the coefficient of friction is roughly constant.

The coefficient should be established, if possible, as it would permit predicting power consumption for sizes other than those tested. Perhaps the difficulty in arriving at a constant coefficient of friction, when going from one size to another, results from using the shaft diameter as a reference, an illogical practice established in comparing bushings and ball bearings. The shaft diameter can be changed without any modification of the bearing (or its friction) by simply making the inner ring thicker or inserting a bushing.

After all, a coefficient of friction is not a physical entity by itself but only a ratio which need not be constant. but the author has already stated that it is roughly constant.

A more logical attack would be to use the pitch diameter of the bearing as a basis, assuming that the frictional effects are roughly divided between inner-race and outer-race contacts. Such a basis gives more constant and useful results.

For example, the author points out that the friction torque varies less with increase in bearing size than might be expected. This occurs because of two conflicting effects, (1) an increase in torque with increased pitch diameter, the effective friction taking place at a larger radius, and (2) a decrease in friction torque because of reduced intensity of loading, resulting from the much larger bearing capacity for the same load.

Ball-bearing theory indicates an increase of race friction with intensity of loading, because increased contact areas mean more differentials in speed between different points in the contact area. It is proposed that, for any given type of bearing, we could draw a single curve of coefficient of friction against intensity of loading that would apply quite closely for all variations in size and loading.

Fig. 1 of this discussion attempts to present such curves taken directly from the author's Fig. 4, using approximate data from the maker's catalog. In spite of the difficulty of reading the original curves and the approximations used, a fairly definite single curve is indicated for each bearing type. The expected increase with load intensity indicates, likewise, an expected increase at very low loads where friction exists even without any load.

Fig. 2, of this discussion, shows a similar set of curves, developed by the writer's company, for controllable propeller work, where only maximum starting friction is measured. The top two curves show correlation between two different sizes of similar bearings. These are of the angular-contact type with extremely close curvatures. The falling off at high load intensity results from a rapid increase in contact angle.

Comparing the top three curves with the lower pair confirms the author's conclusions, from his Fig. 7, that ball-thrust bearings show lower friction than angular-contact type. We would add that closer curvatures increase friction considerably, as shown in Fig. 2 of this discussion.

The entire subject needs further analysis. The friction of antifriction bearings consists of three parts:

1 One component varying with the load and usually the largest, i.e., in ball bearings, the friction due to speed differentials of race and ball surface; again, in tapered or self-aligning rollers, the guiding-flange friction.

2 Friction components not varying with load, mainly lubricant churning.

3 Friction of cages, etc., varying with mounting conditions. For example the top curve (NM70) third part, Fig. 4 of the paper, could be exactly represented by the equation.

Friction equals 1.8 in-lb plus 0.00064 (load) indicating a constant loss 1.8 in-lb, representing the second and third factors described, and a truly constant coefficient of friction for the remainder, representing the first factor. A constant coefficient of friction is to be expected for cylin-

[1] Assistant Chief Engineer, Marlin Rockwell Corporation, Jamestown, N. Y.

[2] "Friction Torque in Ball and Roller Bearings," by Haakon Styri, MECHANICAL ENGINEERING, December, 1940, pp. 886–890.

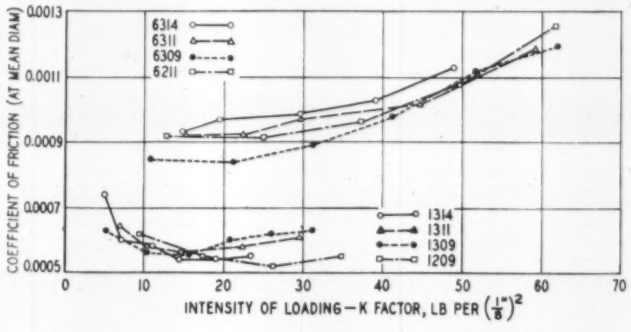


FIG. 1 COEFFICIENT OF FRICTION VERSUS INTENSITY OF LOADING

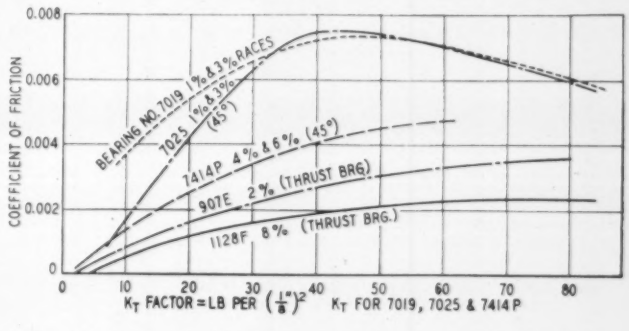


FIG. 2 COEFFICIENT-OF-FRICTION VARIATION WITH K FACTOR

drical roller bearings, since the contact-area width does not change with load.

A similar equation is used by the National Electrical Manufacturers' Association (N.E.M.A.) for deep-well-pump motors derived from friction test data submitted by several bearing manufacturers. The N.E.M.A. equation calculates only the additional losses that vary with load, because all the constant losses are included in the no-load losses of the motor.

Another general conclusion roughly indicated by the author's data is that higher friction usually accompanies higher capacity (except for the cylindrical rollers). Certainly in any one type, closer curvatures yield more capacity and more friction.

In 1938, to investigate this division of ball-bearing friction in its components, S. W. Herwald attempted to isolate the ball-race friction as a thesis problem at Case. The test method used only two balls in dry races with no cage or lubricant and a swinging damped pendulum for loading and measuring friction. Fig.

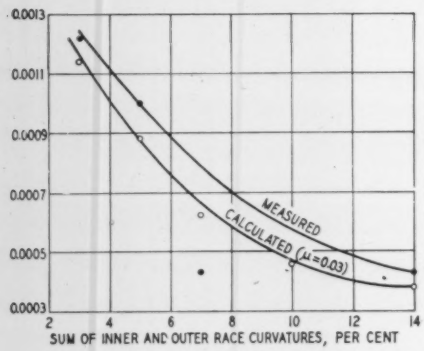


FIG. 3 COEFFICIENT-OF-FRICTION VARIATION WITH CURVATURE
(Ball bearings; balls and races only.)

3 of this discussion shows one typical curve giving the variation of coefficient of friction with curvature. Also are shown the calculation of this friction, using the complicated Sjovall theory and a sliding friction coefficient of 0.03. Note the close agreement with Fig. 1 of this discussion, that is, approximately 0.001 for the same intensity of loading.

COMMENT BY T. C. DELAVAL-CROW[3]

The frictional torque in ball bearings is negligible for most types of applications. Even in the most sensitive types of instruments, the frictional losses in ball bearings, by careful consideration of the application problems and correct control of lubrication, can be made to meet the requirements of extreme sensitivity.

As mentioned by the author, the bearing friction remains practically constant with speed, except at the extremely high speeds the windage resistance of the ball and separator assembly contributes to the total power loss.

The type of lubricant used has considerable effect on the bearing friction. Therefore, the viscosity index, or change of viscosity of the lubricant with temperature, is very important in the case of oil lubrication, especially in applications where a wide range of temperatures is encountered.

In the larger-size bearings, frictional losses are relatively unimportant in comparison with the losses in the rest of the mechanism, and also ample power is always available. There are, however, many modern applications, involving the smaller sizes of bearings, in which the power input is extremely small, and the frictional losses in the bearings, due to the lubricant, become of major importance. Furthermore, the fluid frictional losses in the lubricant have to be considered over a wide range of operating temperatures and speeds.

In many of these applications, due to range of temperatures and types of mountings, grease lubrication is necessary, which necessitates very close control over the amount of lubricant present and the physical characteristics of the grease itself.

Test experience indicates that, in any investigation of frictional losses in small-size bearings, over a wide range of temperatures and speeds, other means of measurement than the conventional cradle dynamometer are necessary.

COMMENT BY E. M. HIGGINS[4]

As the author states, there is but little information available on the subject matter of this paper. The findings therein are of great value to bearing manufacturers, particularly to bearing designers. The work accomplished thus far is frankly not an attempt to classify lubricants.

One of the most interesting features of the author's investigation is shown in his Fig. 8, where the heaviest oil used showed lower torque readings than the medium oil. It is hoped that reports of further investigation of these findings will eventually be available as they are contrary to results usually obtained in general lubrication practice.

The field of coverage for antifriction bearings is constantly increasing and with it interest in the subject of lubrication. Very little lubrication engineering information has been published by engineering societies, publicity of this sort has been mostly confined to individual company advertising with little variance in the subject matter.

What seem to be the best field results are being obtained by equipment manufacturers who study their own problems, assisted possibly by competent lubrication engineers, and then make every effort to see that their choice of lubricants and methods of application are carried out in service.

To begin to handle these problems while equipment is in the blueprint stage has eliminated many of our previous troubles. It is much easier to change a print than it is to make alterations after construction of the unit is completed.

It is difficult to chart even general lubrication recommendations for antifriction bearings, there are so many combinations of operating variables.

Much work has been accomplished during the last few years in the improvement of lubricants for this purpose and in the training of maintenance men in proper handling. There is still much room for improvement.

It would seem that the A.S.M.E. should broaden the scope of Dr. Styri's work, extending it to include lubricant qualifications for various operating conditions, methods of application, etc., bringing recommendations closer to proper specification than are generally published at this time.

COMMENT BY WELLER JOHNSON[5]

Tests have been made at the University of California to determine the friction torque of angular-contact thrust ball bearings. This type of bearing is used extensively in vertical deep-well pumps where the magnitude of the friction losses becomes appreciable under certain conditions.

On the basis of this accumulated experimental evidence, we are in complete agreement with the author in his statement that the amount and viscosity of the oil used have a great effect on the friction torque. We also find that the speed of rotation has only a small effect on the friction for thin-film lubrication.

Our experimental results lead to the conclusion that the operating temperature of the bearing has a relatively large effect on the friction torque. Referring to the curves given in the paper, there is a temperature variation of 4 to 5 C. This variation may have an appreciable effect

[3] Chief Engineer, New Departure Division, General Motors Corporation, Bristol, Conn.

[4] New England Manager, Master Lubricants Company, Philadelphia, Pa. Associate A.S.M.E.

[5] Teaching Assistant, Department of Mechanical Engineering, University of California, Berkeley, Calif.

on the friction torque, as indicated by Fig. 4 of this discussion. The curve is concave upward and is somewhat similar to the viscosity-temperature curve for the lubricating oil used. This really indicates a relationship between friction torque and viscosity of the oil.

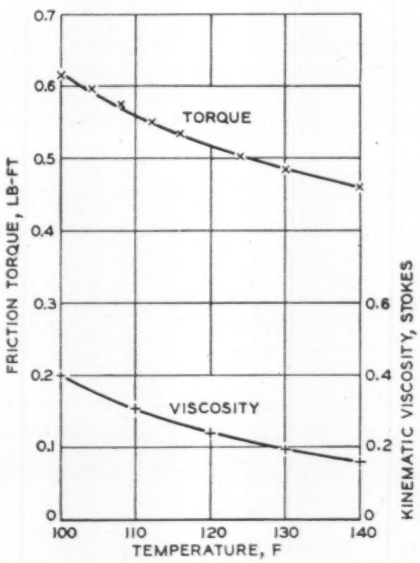


FIG. 4 CURVES SHOWING, AT TOP, FRICTION TORQUE AS FUNCTION OF BEARING TEMPERATURE, AND BELOW, KINEMATIC VISCOSITY OF OIL USED

(Angular-contact type; bearing No. 215; speed 1800 rpm; load 2000 lb.)

The bearing temperatures shown on the curve were obtained by means of thermocouples located at the outer race of the bearings. In this connection, it would be of interest to know how, and at what points, the temperatures as given by the author were obtained.

Several variables affecting friction torque have been mentioned by the author. It seems necessary to add two more, namely, alignment and retainer-ring or cage construction. That misalignment will affect the friction goes without saying and, from the tests made here, it is apparent that the construction of the retainer ring does have a definite effect on the friction torque.

The coefficient of friction, referred to the pitch diameter of the bearing rather than shaft diameter, seems to be a logical approach to the problem since, once established, it may be used to predict power losses in sizes of bearings other than those tested. The curves given by the author show, in all cases, some increase of friction torque with increase of bearing size, thus indicating a relationship between friction torque and size of bearing.

Use of the coefficient of friction is justified if it is more convenient in practice than the friction torque. If the coefficient were constant, it would obviously represent a tremendous simplification as compared with the necessity of testing every size and type of bearing to determine the friction torque. Not being constant, the next question, regarding the coefficient of friction, is whether it varies in any simple manner with size in each type of bearing. This would seem to be the next logical step in a research program.

The number of graphs necessary to present the data on the frictional characteristics of ball bearings appears to be fewer when expressed in terms of the friction coefficient than in terms of friction torque and, consequently, the former would appear to be preferable.

COMMENT BY G. B. KARELITZ[6]

The data published by the author give long-needed information on the actual friction torques encountered in ball and roller bearings, at least in those of standard design, and under conditions in which the bearings should be used in service. Indications are also given as to how to evaluate the friction in other bearings of similar types. The practical importance of the published data is self-evident.

The author has always advocated the use of torque instead of coefficient of friction. It seems to the writer that an important argument for this practice is the uncertainty of the radius of reference. One coefficient of friction would be found if the friction force were considered to act at the inner race; another at the outer race; a third at the ball or roller-center circle. The same difficulty would arise if a coefficient of friction were sought for a bearing with a floating bushing. All difficulties with recording and referring to friction-test data disappear when the torque is given in lb-in. or similar units.

Büche[7] suggested that, with an oil film, there is a separation between the rollers and the races. He evaluated the thickness of the load-carrying films for various loads and speeds and estimated the friction torque which would be caused by the hydraulic friction in the films. He suggested also how to separate the friction at the points of contact, between the rollers and races, and the viscous friction in the films, existing between the rollers and the cage. Even without churning, this latter friction will increase when the amount of oil to the bearing is increased, and the spaces between the rollers and cage are filled with oil.

Büche gives the following formula for friction torques in roller bearings:

1 Friction torque due to rolling on races

$$T' = 6.5\,\mu n U^2 C \sqrt{\frac{r}{s}} + 3.5 \sqrt[5]{W n^4 U^9 C^4 \mu^4 \left(\frac{r}{s}\right)^{1.5}}$$

2 Friction torque at no load due to rolling

$$T'_0 = 6.5\,\mu n U^2 C \sqrt{\frac{r}{s}}$$

3 If the total measured torque at no load is T_0, the friction in the cage is $T_c = T_0 - T'_0$.

4 Total friction torque of bearing for load W is

$$T = T_c + 6.5\,\mu n U^2 C \sqrt{\frac{r}{s}} + 3.5 \sqrt[5]{W n^4 U^9 C^4 \mu^4 \left(\frac{r}{s}\right)^{1.5}}$$

where μ = viscosity, psi per sec; n = number of rollers; U = linear velocity of inner race, in. per sec; C = width of roller, in.; r = radius of roller, in.; s = radial play = $\frac{1}{2}$ total diametral play in bearing, in.; W = load carried, lb; T = friction torque, lb-in.

The formulas are approximate, good for bearings, where $100 \leqslant \frac{Ws}{\mu U r n C} \leqslant 5000$.

Büche believes that the formulas found experimental confirmation in his analysis of published data on friction in roller bearings. It would be interesting to compare the formulas with the observations of the author, if the necessary values have been recorded or can be derived from the available records.

COMMENT BY C. C. ROSS[8]

Some years ago, the writer attempted to determine the friction of rollers on turf using the coefficient-of-friction method but found it impossible to get consistent results. Doubtless, the determination of the friction of rollers on turf is even more complicated than of bearings. While it is probable that the author's torque results will be quite as useful as coefficient-of-friction results, the writer does not believe we should condemn the latter method. It is desirable, from the pure engineering standpoint, to correlate the results of the two methods.

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[6] Professor of Mechanical Engineering, Columbia University, New York, N. Y. Mem. A.S.M.E.

[7] "Hydrodynamic Theory of Friction in Roller Bearings," by W. Büche, *Forschung auf dem Gebiete des Ingenieurwesens*, vol. 5, 1934, pp. 237–244.

[8] Consulting Engineer, Rochester, N. Y. Mem. A.S.M.E.

The writer also ran tests on a ball bearing of approximately the same size as those used by the author to determine the desirable level for the lubricant and found that the lowest power consumption was to be had when the oil level was just above the inside of the outer race at its lowest point. Any increase in this level increased the power-input requirements, as well as the temperature and the churning effect on the oil. When the level reached the center of the lowest ball, it was evident that the oil was too high, the oil in the sump becoming covered with froth. On lowering the oil level, the power requirement and the temperature decreased, and the oil in the bath again became normal.

Many years of experience suggest that ideal lubrication would be secured if we could have but a fog of oil within the bearing, which condition would be very similar to that in the tests described when there was but a slight amount of oil present.

COMMENT BY G. A. UNGAR[9]

The suggestion to use friction torque, rather than the coefficient of friction, is so logical that there should be no argument against it. Its general adoption should produce valuable additional data for the comparison of different types and makes of rolling-contact bearings.

The author has given very interesting data on the influence of lubricants and methods of lubrication upon friction torque. It would be of considerable value to know what effect upon friction torque is exercised by the surface finish of races and rolling elements. In view of the adoption of superfinishes for rolling-contact bearing on a rapidly increasing scale, comparison with the regular surface finishes should be possible by means of friction-torque readings. At the same time, it should be possible to determine how long the effects of superfinishes will be noticeable by actual friction-torque readings; in other words, what effect does superfinish have on ultimate bearing life?

The tests described were apparently made with clean lubricants, but it would seem to be evident that lubricant oxidation, sludge formation, and the effect of abraded metal from retainers or race and rolling elements would have a pronounced effect upon friction torque. Actual figures for permissible friction-torque increase would be of considerable interest.

This brings up the somewhat controversial question of bearing-life determination. The experience of the bearing manufacturers in testing and operating large numbers and types of bearings should make it possible to determine when friction-torque increase becomes sufficient to indicate approaching bearing failure. Continuous friction-torque readings should, therefore, provide a possible basis for the adoption of a uniform method to determine bearing failure. This might be done by establishing the failure point as a multiple of the initial friction torque, the multiple depending upon the number of bearings tested simultaneously in one testing machine.

With the establishment of a uniform test procedure for the failure point for which friction-torque readings may present the desired basis, it should be possible also to establish a uniform basis upon which the ratings of rolling-contact bearings could be established, so as to eliminate the strange discrepancies which confront the user of bearings when comparing load ratings of different manufacturers.

The reason for these discrepancies is quite well known to bearing engineers, but they are not quite so readily understood by the average designer. We find bearing ratings based on either average or minimum life expectancies. We find that life tests are conducted either with regular lubricant renewal or without any addition of fresh lubricant. We find ratings based on a wide variety of hours of life expectancy, ranging from 2500 to 10,000 hr of average life or on 3000 hr of minimum life. We also find a wide variation in the percentages of failures in a group of tested bearings used as a basis for life-expectancy data.

To provide an illustration for the results of this condition, the writer presents Fig. 5, showing the plotted catalog ratings of three manufacturers of their No. 210 S.A.E. single-row ball bearings. The bearings have the same number of balls of the same diameter. They are all precision bearings made from S.A.E. 52100 steel heat-treated to approximately identical hardness. The load ratings should, therefore, differ only very little. Actually, they show considerable variations and this is due to the fact that the ratings are based on different life expectancies, i.e., 2500, 3500, and 5000 hr.

The writer believes the time to be more than ripe for an agreement among bearing manufacturers on a method of load ratings which will permit of ready comparison of different types and makes of bearings.

When called upon to make an intelligent comparison between different bearings, it has been the writer's practice to convert the different manufacturers' ratings to the same average or minimum life expectancy and then to take into consideration the space occupied by the bearings. This is done by dividing the corrected load ratings by the projected bearing area. This quotient is a true criterion for the load-carrying capacity of a rolling-contact bearing, expressed in pounds per square inch, and permits of a ready comparison of different bearing types on a basis important to the designer. There are other criteria of comparison but these do not come within the scope of this discussion.

It is to be hoped that the author's proposal will lead to the establishment of a more uniform method of comparing bearing types.

AUTHOR'S CLOSURE

The author appreciates greatly the various comments which give side lights to data reported in the paper, and also the opportunity for brief rebuttal of the arguments in the order in which they were presented.

In reference to the comments by Mr. Barish, the author was careful to state in the paper that the friction torque varied almost "linearly" with the load but at a somewhat faster rate, depending upon the type of bearing. This, of course, is different from having the torque "proportional" to the load, although for a short stretch it may be nearly "proportional." The difference in calculated values of the coefficient, due to linear or due to proportional variation, is obvious, particularly when load values are used which are most frequently ap-

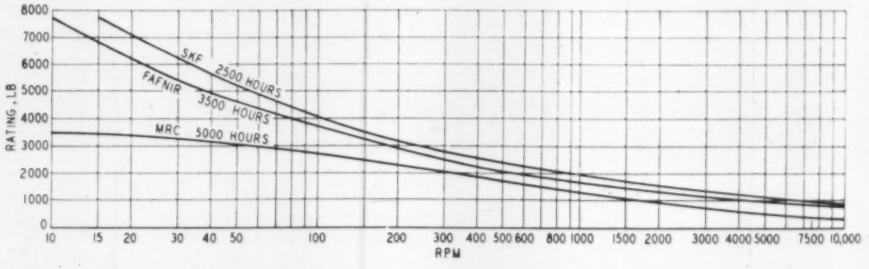


FIG. 5 CATALOG RATINGS FOR AVERAGE LINES OF DIFFERENT BEARINGS
(No. 210 single-row deep-groove bearing with ten 1/2-in. balls.)

[9] Consulting Mechanical Engineer, New York, N. Y. Mem. A.S.M.E.

plied in technical installations. The coefficients, shown in Fig. 6 of this closure, are for conventional reasons calculated with reference to the shaft diame-

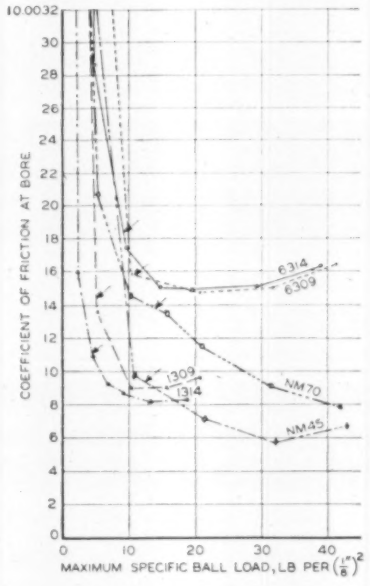


FIG. 6 COEFFICIENTS OF FRICTION CALCULATED WITH REFERENCE TO SHAFT DIAMETER

ter from the test results on some of the bearings which were run with small amounts of lubricant. The use of any other reference diameter would, of course, only change the numerical values of the coefficient. Using the pitch diameter is objectionable because it cannot be measured directly and is not given in current catalogs, and there would probably be some argument in choosing the pitch diameter for spherical roller bearings and tapered roller bearings. As a matter of interest for those who prefer coefficients of friction, there is an advantage in referring it to the outside diameter of the bearings, because the carrying capacities of bearings of the same type but of different series are quite close for the same outside diameter.

The highest load values, given in Fig. 6 of this closure, are approximately those for 10 per cent failure at 500 hr and 1800 rpm from the maker's catalog, and load values for 50,000 hr and the same conditions are indicated by arrows. Ball and roller bearings are, of course, frequently used at much lower loads than these and only very rarely at the higher loads. It is evident that the coefficient remains relatively constant for any one bearing, and fairly close for all bearings of the same type only in a limited range of high loads. For the lighter loads, which are most frequently used, the coefficient increases at a growing rate for a decreasing load.

Mr. Barish has not given details of the test conditions for thrust bearings, shown in his Fig. 2, which indicate that he has obtained a coefficient of friction approaching 0 or even less for decreasing values of specific loads, and going through a maximum for some higher values of specific loads. This differs with results of the tests on thrust bearings, reported in the paper, where the coefficients of friction (referred to shaft) are shown to increase toward lower loads, Fig. 7 of this closure.

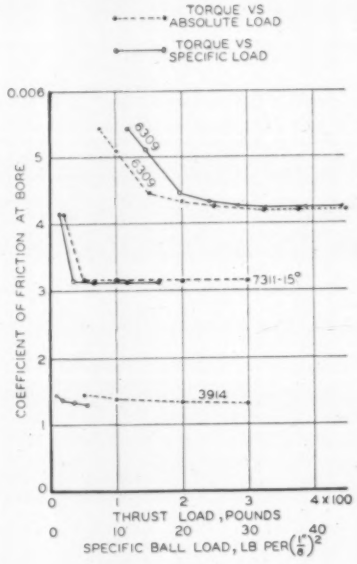


FIG. 7 RESULTS OF COEFFICIENT-OF-FRICTION TESTS ON THRUST BEARINGS

It is, of course, useful to have some knowledge about the coefficient of friction in ball or roller bearings, referred to the shaft diameter, in order to make a comparison with journal bearings. The selection of some other diameter for reference such as pitch diameter or outside diameter would reduce the numerical value of the coefficient but would also increase the confusion. The preference for the friction torque which makes any reference to a diameter unnecessary, has, therefore, been emphasized in the paper.

The torque can be estimated approximately by empirical equations of the type $T = aP + bP^2$, as follows, for instance, for standard ball bearings under radial load:

For single-row groove bearings

$$T = 0.001\ P + 0.0000003\ P^2$$

For self-aligning bearings

$$T = 0.0006\ P + 0.00000013\ P^2$$

where T = torque, lb-in.
P = radial load, lb

Three- or four-term equations, separating the effect of design, load, and lubricant may, of course, also be developed.

In a ball or roller bearing, there are many parts which have motion relative to other parts and which, therefore, will cause friction. The present paper is an effort to evaluate the total sum of these frictional forces under different operating conditions in a simple but adequate manner. As mentioned, it was considered beyond the scope of the paper to include the effect of many factors which influence the friction. A determination of friction in unlubricated bearings would seem irrevelant because such bearings would fail in service.

Mr. Delaval-Crow points out the importance of viscosity of oil on the friction. It is even more important to control the quantity of oil in the bearing. Both of these factors affect the friction and, therefore, the operating temperature of the bearing.

Mr. Higgins notes the unexpected result of higher friction with the medium oil than with a heavier oil of another type. A repeat test with oils of the same type but of different viscosity gave the expected result that friction increased with viscosity. Evidently the medium oil used in the original test has different thin-film properties from the other oils and seems to cling to the surface more tenaciously.

Referring to Mr. Johnson's comments, the temperatures were measured by contact thermocouples on the outside of the housing near the top. With the testing equipment available it was not possible to keep the same temperature for the different operating conditions. Therefore, a test condition would be selected which would allow a series of torque measurements to be made rapidly for other speeds and loads without too great temperature changes. From a re-

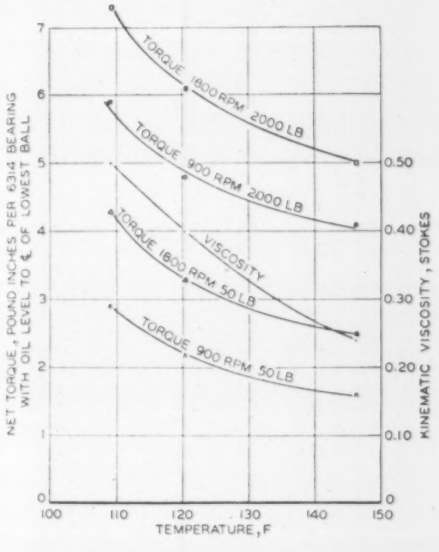

NET TORQUE, POUND INCHES PER 6314 BEARING WITH OIL LEVEL TO ¼ OF LOWEST BALL
KINEMATIC VISCOSITY, STOKES
TEMPERATURE, F
TORQUE 1800 RPM 2000 LB
TORQUE 900 RPM 2000 LB
VISCOSITY
TORQUE 1800 RPM 50 LB
TORQUE 900 RPM 50 LB

FIG. 8 REPLOT OF TORQUE AGAINST MEASURED TEMPERATURES OF 6314 BEARING

plot of torques against measured temperatures of the 6314 bearing, mounted in pillow blocks shown in Fig. 8 of this closure, the effect on friction torque for 5 F difference in temperature can readily be seen. Of course, the torque changes with the viscosity of the oil but not proportionately. The velocity of rotation and design would also influence the result. A larger bearing generally has higher friction torque than a smaller bearing, but not always. It depends also upon the absolute load used and upon the difference in size of the bearings.

The complicated formula established by Büche, which Prof. Karelitz refers to, does not correspond to results obtained in our experiments for the following reasons:

With film lubrication, the friction torque is independent of speed (the Büche formula has the square of speed as a factor in one term and $U^{3/4}$ in another).

The torque is independent of ball number.

The torque increases a little faster than linearly with the load.

Except for light loads, the radial clearance does not materially affect the torque.

Torque is not proportional to viscosity of oil.

For those wishing to check the numerical values of Büche's equation, the dimensions needed, for instance, in the NM 65 bearing are $n = 12$, $c = 0.748$ in., $r = 0.374$ in., U at 1800 rpm or 30 rps = 310 in. per sec, $s = 0.001$ in.

An oil level just reaching the land of the outer race or a fog of oil, as suggested by Mr. Ross, does not give the lowest friction. Considerably less oil may be used by slow drop feed but there is a critical low limit for adding oil, which if passed will cause failure of the bearing.

With reference to Mr. Ungar's suggestion as to the effect on friction of various finishes of the races, it may be stated that there is no noticeable difference on the friction torque between standard finish and superfinish, which probably is due to the presence of the always necessary thin oil film. Change in friction torque cannot be used to indicate the fatigue failure of a bearing, but may serve to show lubrication failures by a rapid increase in temperature. Since the endurance or life rating cannot be determined by measuring the friction torque, it is felt that further comments on load rating and life expectancy are out of place in this discussion.

HAAKON STYRI.[10]

[10] Director of Research, SKF Industries, Inc., Philadelphia, Pa. Mem. A.S.M.E.

Wood-Burning Space Heaters

COMMENT BY E. L. HEERMANCE[11]

As noted in the paper,[12] improved equipment for burning wood has been a case of starting with an economic need and setting engineers to work in a way to meet it. Some years ago, Germany was confronted with a surplus of cordwood from forestry operations. To increase the market for this class of material, the central technical laboratory devised an improved type of wood-burning stove, now in common use in Europe. America is facing the same problem. The bottleneck of forestry has been the lack of a market for the cordwood which should be taken out in improvement cuttings. New markets for wood had to be created. One of the possibilities, as in Germany, was a satisfactory wood-burning stove. Technical experts were again called into action, and the Yale School of Engineering developed a stove, based on the distillation principle, which is adapted to American needs.

This new wood-burning stove has aroused a surprising amount of interest throughout the country; partly because it is a valuable piece of equipment for many householders in rural areas; partly because it opens up a use for immense supplies of fuel now going to waste. In Connecticut alone our woodlands are producing each year at least 300,000 cords of wood for which there is no market. In heat value that is the equivalent of 300,000 tons of coal. At least we have made a start in developing wood-burning stoves and furnaces which are both efficient and convenient. As fast as that can be done, wood will begin to come back as a domestic fuel in timbered areas where transportation costs make coal and oil relatively high in price.

The same thing is true of industrial fuel. Our association, in cooperation with state and Federal agencies, is now experimenting with hogged wood, that is, cordwood reduced to chips in a machine known as a hog. Wood in this form can be fed mechanically to a boiler. Where a factory or institution is paying over $6 per ton for coal, hogged wood is probably a cheaper fuel. We are also experimenting with methods by which the cost of producing fuel wood can be reduced.

The Society is to be commended on the attention it is giving to this problem, with its important economic and social aspects. Wood fuel is here at our doors. We need to make use of it, in order to reduce fuel costs and at the same time build up our forests. The next few years are likely to see a great deal of research on wood combustion, for which the authors have blazed the trail.

[11] Secretary, Connecticut Forest and Park Association, New Haven, Conn.

[12] "Wood-Burning Space Heaters," by L. E. Seeley and F. W. Keator, MECHANICAL ENGINEERING, December, 1940, pp. 864–870.

COMMENT BY D. E. HOWES[13]

The authors are to be commended for pioneering in a field which has been practically ignored by engineers, and it is to be earnestly hoped that they will accomplish all three of their objectives. The economic importance of wood as a fuel does not seem to be fully appreciated.

Anyone having had experience with wood burners, operating on the general principle described in this paper, cannot help but be impressed by the steady heat and infrequent attention necessary, as compared with those with which most of us associate domestic wood burning. This fact encourages one to believe it is worth while for engineers to study it for the purpose of making use of its good features and overcoming its faults; for it does have some of the latter.

The writer has made some tests with the type A heater and, in general, the results confirm the authors'.

The authors lay great stress on secondary air for combustion. Experience with fuels of high volatile content certainly leads one to this same conclusion. However, under some conditions, this does not seem so important. Consider the operation of a typical heater. In the process of distillation, from 25 to 28 per cent of the weight of the wood is given off as noncondensable gases, primarily CO_2 and CO, but also some hydrogen and hydrocarbons. The relative quantities of each depend upon the temperature of distillation. All of these gases have an ignition temperature of at least 1100 F or above. Furthermore, the so-called pyroligneous acid, 45 or 50 per cent by weight, is largely water vapor, but among other things contains tar in suspension. Also the water vapor, due to moisture in the wood itself, is frequently mixed with the foregoing combination. Because of the high percentage of water vapor and CO_2, the mixture may be nonflammable and certainly is not ignited below 1100 F; no matter how much air is mixed with it.

If the temperature at the outlet of the magazine is measured, it will be found that, except for the higher rates of combustion, it is lower than 1100 F. It is at this point that secondary air is introduced in both models of the heater.

[13] Norwich University, Northfield, Vermont.

Thus, it is seen that, during much of the operation, the only result of the secondary air is to dilute the distillation products and carry them off as a part of the flue gas. One can observe this by looking through a glass wall into the magazine. The smoke will be seen to pass over and through the glowing coals as though they were not present at all. As a matter of fact, the distillation products will tend to cool off the passageway from the magazine. Analysis of the flue gas under these conditions by the Orsat apparatus will reveal a quite high CO_2 and considerable CO, but it is primarily the distillation gases being measured rather than products of combustion as ordinarily considered. What has been described takes place during the first 3 to 4 hr after the heater is charged and under conditions of relatively low heat release. This will always be accompanied by tar formation, either in the heater or in the chimney.

If the rate of combustion is sufficiently rapid relative to the rate of distillation, the products will be ignited and good combustion will result. Of course, presence of excessive moisture in the wood itself aggravates the whole situation. The obvious solution is to maintain a certain minimum rate of combustion and less than a certain maximum rate of distillation at all times if possible by preventing most of the body of wood in the magazine from reaching the temperature at which distillation begins, or at least below the exothermic-reaction temperature of about 500 F. Whether these two conditions are attainable in a practical heater has yet to be determined.

After distillation is practically complete and charcoal is being burned, the situation within the magazine is entirely different. Charcoal will ignite at a low temperature, about 500 F, and will burn efficiently at temperatures below the ignition point of all gases which might be in the distillation products. This is true slow combustion. At low temperatures, the charcoal burns largely to CO_2 but, as the temperature is elevated, more CO is formed which will not be ignited unless the temperature within the combustion zone is at least 1100 F. This may account for the presence of CO in all the flue-gas analyses which the authors mention.

The foregoing considerations led to a modification of the grate to be used in a wood burner of the type under discussion. Ideally, the grate should help to maintain a hot combustion zone and should provide a well-distributed air supply to the fuel bed. Too large openings in the grate will give an excess of air and will allow charcoal particles to fall through. Small openings will operate in an excellent manner for a short time after cleaning, but will then become clogged by ashes. After several designs were tried, it was decided to abandon the usual concept of grate. The result is shown in Fig. 1 of this discussion.

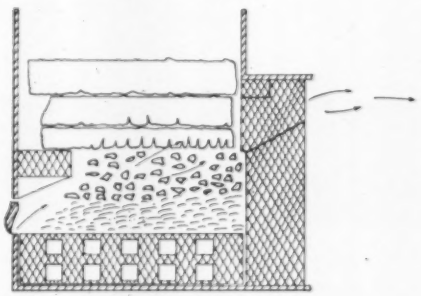


FIG. 1 SECTION OF GRATE

The purpose of the shelf, shown in Fig. 1, at the front, is primarily to prevent the air from rising up and burning the wood in the front part of the magazine first. It tends to keep combustion over the bottom of the fuel pile quite uniform. By allowing the ashes to pile up as indicated, live coals of charcoal will become embedded at the base of the fuel. These will burn slowly and will help hold a fire for days. If kept warm enough, however, by the fire above they will burn completely even though they are entirely covered with ashes. Every day or two, by means of a special tool, part of the ashes are removed from the bottom of the pile, thus lowering the fuel bed to the proper level with respect to the magazine outlet. The wood is laid lengthwise and the air supply comes in at the front rather than underneath. The air flow through the fuel bed is dependent upon the latter and not upon the grate. The charcoal in the fuel bed is of surprisingly uniform particle size and the air flow through it, over approximately 1 ft of length, is very satisfactory. No secondary-air supply is needed, because there are enough holes through the fuel bed or between the sticks of wood for this purpose. This must seem to be a rather unscientific arrangement, but it should be remembered that wood as commonly supplied has not been very scientifically prepared. As the rate of combustion is varied from about 1 lb per hr per sq ft of grate area to about 5, the CO_2 varied from around 7 up to 13 per cent, which is considered quite satisfactory.

These are average results, but anyone familiar with such measurements knows that wide variations may be encountered depending upon the particular fuel-bed conditions. Fuels ranging from dry softwood slabs to large hardwood chunks have been used quite satisfactorily.

While no method of rating heaters seems to have been officially recognized, it is doubtful whether the one used is the best choice. It would seem better, for instance, that when we rate a heater at 20,000 Btu per hr, we should mean that, under certain specified conditions, it would impart a useful heating effect of 20,000 Btu per hr. This would be consistent with the methods for rating boilers and furnaces. The subject of heater rating might properly be discussed further with this in mind.

It might be mentioned that the observations contained in this discussion were made in connection with attempts to apply the principles to the design of a wood-burning furnace. The development is being continued.

COMMENT[14] BY P. NICHOLLS[15]

The writer understands that stove A has been on the market for some time. How many have been sold and what has been their general success or, rather, have there been difficulties, particularly in connection with the attendance?

Probably there is a simple explanation of the persistent presence of CO in the exhaust gases, even when there is a large excess of air. The inner door which closes the top of the magazine has no special seal and, thus, there will be cracks. Also, there will be a difference in pressure between the top horizontal flue and the magazine, which will tend to draw gases from the magazine into the flue; these gases will contain combustibles which may not ignite at the temperature in the flue.

This leakage of gas will also explain why the gas analyses, in Table 2 of the paper, do not show an oxygen deficiency of 2 to 3 per cent, as would be required by the analyses of the woods given in Table 3.

The paper intimates that there is rapid distillation of the wood in the magazine; can this be expressed as percentage of volatile distilled against time? It would be thought preferable to insulate the magazine from the heat so that the distillation could be distributed over a long period.

Has there been any trouble from explosion of gases in the magazine? Usually, the combustible gases would exceed the explosive limit, but at times there might be an explosive mixture.

Personally, the writer questions whether a design of furnace illustrated by

[14] Published by permission of the Director, Bureau of Mines, U. S. Department of the Interior.

[15] Supervising Fuel Engineer, Bureau of Mines, Central Experiment Station, Pittsburgh, Pa. Mem. A.S.M.E.

type A of the paper is necessarily the best. The principles of cross-feed burning and the thorough mixing of the products of combustion with the secondary air are correct, but the writer fails to see the advantage of the magazine opening into the gas chamber. Why should not the door for the magazine be at the rear of the furnace and be made so that it will be sealed tightly by packings? If, in addition, the damper for the air supply was made so that it could be closed temporarily when firing by a quick operation of lever and spring, the effect would be for the stack draft to draw air through the magazine and thus avoid emission of smoke.

COMMENT BY C. P. WINSLOW[16]

The work represented by this paper is thoroughgoing, and the results are conclusive and significant. Aside from certain minor points, such as those relating to the end products of wood distillation, which have no essential bearing on the conclusions, no occasion for any disagreement occurs.

Nor is there any gainsaying two of the three objectives outlined in the paper. The first one, however, might well be discussed from an angle somewhat broader than that of the authors.

Engineering interest should not by any means be confined to the conception of a space heater, as defined by the authors. The domestic stove as we have known it in the past is admittedly important today and in the transitional stage that will be with us for a certain length of time; but it seems doubtful that relatively minor improvements in burning efficiency and frequency of feed will play a major part in improving the status of wood fuel either as a matter of domestic economy or an outlet for waste wood.

The desirability of more fundamental changes must be recognized, and ways and means worked out. The idea itself of a space heater in the sense of a stove that must either take up too much room or be moved in and out of the room as the season changes is hardly in accord with what it is reasonable to suppose the public expects from modern engineering service. Compared with what one gets from small unobtrusive burners that one finds tucked away in a utility room in a modernly designed low-cost home, the so-called space heater in any modification of the old wood stove is seriously outmoded.

The engineering problem of the modern use of wood as a fuel starts in the forest in the development of the most economical method of processing and handling the material all along the line to the burner. In the past, hand labor has been excessive; sawing, piling, resawing, splitting, repiling, etc. At least $1 per cord should be cut from the cost of wood delivered to the consumer. It is within the realm of possibility that machine methods may be developed to accomplish this. Should not new modern burners be designed for the use of small-sized material prepared in this way?

The problem of engineering finds its culmination in taking full advantage of all the good points there are with respect to wood fuel and compensating as far as possible for all the bad points. Perhaps it is not beside the point to mention a few of the good points of which fuller advantage may be taken in the future than is true at present.

1 The wide distribution of wood which should be used and is suitable only for fuel in proximity to large sections of population, especially the farm and village populations.

2 The inherent cleanliness of wood and freedom from dust incident to handling and from soot, smoke, or escaping fumes incident to combustion.

3 The low ash content and the ease of disposal and even the mild fertilizing value to be attached to the ash.

4 The fact that all home builders, no matter how extremely modern in other demands they may be, seem to aspire to at least one wood-burning unit as the center of interest in the home (fireplace).

It remains for engineers to find ways and means of bringing these conditions and assets together in a profitable and practicable combination. Perhaps certain of the principles of the slow-combustion hopper-feed burner, utilizing machine-prepared wood (in a visible-burning chamber) may ultimately prove a good approach.

Although the points touched upon here are somewhat at variance with the conception of a space heater as dealt with in this paper and modifications in the conception would involve modifications in the requirements for modern wood burners, there is no implied criticism of the work reported on in this paper which in the main must be viewed as of a high order. Certainly it is a step in the right direction which must be taken along with other steps to develop adequately the possibilities in fuel-wood utilization.

COMMENT BY H. D. WATSON[17]

The writer would briefly review some of the results which have been obtained with type A stoves in actual practice. Ten such stoves were operated in Connecticut during the last heating season, and also one at the University of Maine, using various kinds of fuels. In general, very good results have been obtained, indicating increased efficiency in the combustion of wood, with much less attention required, due to the infrequent firing periods necessary. It has also been found that green wood may be burned quite satisfactorily, contrary to expectations. The chief difficulty aside from smoke and fly ash encountered during actual firing, which may be eliminated by improved firing methods, is the creosote formed at low operating rates. This is due to low stack temperatures and resultant condensation of the products of combustion. The solution to this problem lies in shortened stacks, pitched slightly from the stove to the chimney or the use of insulated stacks. Some such device is essential, if the stove is to be operated at the relatively low rates which are necessary if it is to maintain uniform temperature.

There is an interesting experiment being conducted in Maine along the lines of conservation and inexpensive heat for domestic heating. This is the use of sawdust in furnaces equipped with mechanical stokers, which is apparently very successful in localities where sawdust is a waste product.

AUTHORS' CLOSURE

The authors are gratified at the interest shown in the paper as evidenced by the discussions. The paper was intended to focus the interest of engineers on the general problem of the efficient and convenient utilization of wood for heating purposes and upon some of the problems involved. The space heater was not viewed as the only heating device to be considered but it was logical to start with such a device because the space heater today is used in numbers far exceeding other heating devices. Furthermore, whatever improvements can be made in the control and character of combustion can be easily applied to circulating heaters and furnaces.

Professor Howes's discussion brings out some of the difficulties of the combustion process very clearly and indicates that there are several ways of supplying air and controlling combustion. His questioning of the method of rating of the heaters is quite proper. The authors had not employed the method of the actual heating effect for the reason that no method had been formulated and it was thought best, for the time being, to confine the data to the heat produced.

Mr. Nicholls in his usually thorough

[16] Director, Forest Products Laboratory, Madison, Wis.

[17] Head, Department of Mechanical Engineering, University of Maine, Orono, Maine. Mem. A.S.M.E.

manner has considered the problem of combustion and suggests that leakage from the magazine cover may account for the continued presence of CO even with large percentages of excess air. The CO cannot be accounted for in this manner because samples taken in the vertical flue show CO which would not have come from the magazine by leakage. It is far more likely that Prof. Howes's explanation is the correct one.

The question of insulating or cooling the magazine is open to some doubt. Insulation would accelerate the exothermic reaction which would result in higher rates of distillation than desirable. How effective cooling of the magazine might be, in holding down the distillation rate, has not been established.

The matter of the magazine door, opening into the gas chamber or flue passage, is very important. A door giving direct access to the magazine introduces a definite hazard of gas explosions. Air must not be allowed to mix with the distilled gases in the upper part of the magazine. An inner door, even if not gastight, precludes the possibility of explosion. No explosions or even incipient explosions were experienced in any of the heaters tested.

Professor Watson's observations on the satisfactory operation with green wood agree with our experience in the field tests. His comments on the need for short chimney connections, pitched from the stove toward the chimney, also agree with our experience. Messrs. Winslow and Heermance have given a clear picture of the problem of securing and marketing wood fuel at reasonable costs. The Connecticut Forest and Park Association and the North Eastern Forestry Experiment Station have started studies calculated to reduce the cost of cutting and handling fuel wood.

It is hoped that in time wood may become a cheap and convenient fuel through the development of special wood-burning heaters.

L. E. SEELEY.[18]
F. W. KEATOR.[19]

[18] Associate Professor of Mechanical Engineering, School of Engineering, Yale University, New Haven, Conn. Mem. A.S.M.E.
[19] Assistant Professor of Mechanical Engineering, School of Engineering, Yale University, New Haven, Conn. Mem. A.S.M.E.

Dr. Lucke Retires

TO THE EDITOR:

With the opening of another college year, a great lecturer will be missed from our family of engineering instructors. In accordance with the "law of the Medes and Persians which altereth not," Dr. Charles E. Lucke, having reached the age of sixty five, has retired from the Columbia School of Engineering and becomes Stevens Professor-Emeritus of Mechanical Engineering. After continuous service of thirty-nine years, it is hard to conceive of this School of Engineering without the active support of Dr. Lucke but it is fortunate that he will continue his active consulting-engineering practice, and since his home is so close to the university he will be available for advice and guidance for many years to come.

Dr. Lucke received his early education in New York City public schools and his first degree from the College of the City of New York. As a graduate student he studied at Cornell, New York, and Columbia universities. He holds the degrees of B.S., M.S., Ph.D., Sc.D., the title of Commander U. S. Navy, and is a member of Phi Beta Kappa, Tau Beta Pi, and Sigma Xi.

He is a Fellow of the A.S.M.E. and a member of many other engineering societies.

Dr. Lucke began his work at Columbia in 1902 as assistant in charge of laboratory courses. He then became instructor, later assistant professor, and at 32 was made professor of mechanical engineering and head of the department. When he retired he was John Cox Stevens Professor of Mechanical Engineering and executive officer of the department. He will be succeeded by Prof. Harry L. Parr as Stevens Professor of Mechanical Engineering and by Prof. Theodore Baumeister, Jr., as executive officer of the department.

CHARLES E. LUCKE

To many who have sat under him, Dr. Lucke is considered possibly the greatest lecturer on mechanical engineering that this country has yet produced. His lectures were never brief and never long-winded. Each lecture completely covered the subject or it was continued in the next period and no lecture was ever repeated except to another section of the class. His lectures were packed with information and hardly a sentence could be neglected by the students of his classes. He is a voracious reader of technical literature and organized and maintained a clipping bureau for his reference and for others of the department. No book remained on his shelves that had not been tested for authoritativeness and that was not necessary for ready reference. If only a chapter was valuable, only that was saved. His entire file of A.S.M.E. Transactions was torn apart and the essential papers filed by subject for more ready reference. He never read a lecture to a class. For each course he had a loose-leaf notebook and notes for each lecture were changed as new material appeared in the press or as he had collected new items from his extensive consulting practice. One of his students remarked, "When Dr. Lucke lectures on Feb. 10, 1941, we can be sure that all technical literature has been reviewed that has been published up to and including midnight Feb. 9, 1941."

He has always hated superficiality and possesses a strong physique and enormous energy. He was at his office every morning at 8 o'clock reviewing the technical literature and marking it for the members of his department. In the conduct of his department he was dictatorial, arbitrary, and frequently unreasonable, but always ready to change his mind or his program when he saw that a suggestion had been well thought out. He was a hard taskmaster but constantly on the lookout for opportunities for advancement or experience for his associates and subordinates and always commanded their respect and loyalty. He fought the other departments tooth and nail and bragged about them to the outside world and always followed the will of the majority. As an engineer familiar with the use of specifications he required each instructor of his department to prepare specifications for each course well in advance of its presentation and these specifications were examined by the department members for overlapping and omissions. In each specification there was given the subject by periods, technical

reference for each period, and reference to all commercial catalogs pertaining to the subject. These specifications later became of the greatest value to the graduate who found it necessary to study further on one of these subjects. He maintained a constantly replenished catalog library and required his students to review the catalogs to give an engineering analysis of the "sales talks." He taught the students to study the engineering literature and read the catalogs when they needed a new machine before they attempted to design one and encouraged Professor Parr to build laboratory testing equipment (listed in catalogs) to illustrate that accuracy can be obtained with appearingly crude apparatus when others are not available. He would not permit a lantern-slide lecture except by an outside lecturer and then with tongue in cheek. He reasoned that the lecturer's back was generally to the class, making the hearing difficult, and that sleepers could not be caught readily. But he always welcomed catalogs and blueprints in any amount and would spend time after hours with any student interested in detail.

His lecture-room door closed on the hour and woe betide the hardy youth that attempted to enter one quarter of a minute later. Lack of student attention meant absence for the rest of the period, and after the first silly question of each new class, all questions were carefully weighed before being offered—he would not waste the time of the others in answering foolish questions. Yet, after hours, or in his office, any question which merited (and received) a stinging rebuke, was answered as completely as in an engineering report.

Twice each year all mechanical-engineering students and their instructors assembled for an inexpensive dinner on a common footing. Usually there was no speakers' table and never did two members of the faculty sit together. They were the students' nights with no regulation except to remember that they were entering the engineering profession and were therefore gentlemen.

No one person will ever know the full story of "the Doctor's" relation with his students. Feared by the freshmen, respected by the juniors, and loved by the seniors, no sacrifice was ever too great for him if a student needed advice and help. Though quick to mete out severe punishment and utterly impatient with insincerity, he was even quicker when concrete help was the answer to the student's problem.

Dr. Lucke's contributions to this Society are too well known to require extensive discussion and though retired as a teacher he will remain active in the Society. His first paper was delivered while he was still a junior member and the Index lists thirteen papers preserved in the "Transactions." He served on many committees of the Society and started the Gas Power Section which was the beginning of the professional divisions, and in recent years started and was the guiding spirit in the study of heat transfer which resulted in the present Heat Transfer Division.

During the World War, on behalf of the U. S. Navy, he established a special training school at Columbia for mechanics and engineer officers and was later put in charge of this work throughout the country and was cited by the Secretary of the Navy and later made Commander, U.S.N.R.F.

It is difficult to specify any one branch in which the Doctor is particularly identified though he is particularly thought of for his contributions to internal-combustion engines, boilers, and heat transfer. Were we to cite one subject we would mention power, remembering that with his thoroughness it meant a complete knowledge of all phases of this subject.

W. A. SHOUDY.[20]

[20] Consulting Engineer, New York, N. Y. Fellow A.S.M.E.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Committee Secretary, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting of the Committee.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and also published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of June 27, 1941, subsequently approved by the Council of The American Society of Mechanical Engineers.

CASE No. 883

(Reopened)

Errata—In the July issue of MECHANICAL ENGINEERING the dimension of the diameter in item (6) of reply should read:

"For item (6) of reply change '$^7/_8$ in.' to '$1^1/_4$ in.'"

CASE No. 933

(*Interpretation of Par. U-39(a)*)

Inquiry: Par. U-37(*c*) requires that cast-iron heads flatter than the limits given in the paragraph shall be designed as flat plates. The flat-head formula in Par. U-39(*a*) refers only to working stresses given in Table U-2, which table does not provide for cast iron. Both tensile and bending stresses are given in the Table in Par. U-13(*g*)(3). Since the stresses in a flat plate are essentially those of a bending nature, and as there is no reference to the use of bending stresses in the Code, may it not be reasonably inferred that the bending stresses may be used in the formulas in Par. U-39(*a*) and in the formula in Par. UA-11, for application to cast-iron flat plates?

Reply: It is the opinion of the Committee that cast-iron flat heads or plates may be designed in accordance with the formula in Par. U-39(*a*) using the bending stresses given in Par. U-13(*g*)(3) for the class of material used. The bending stresses may also be used in the formula in Par. UA-11 when testing flat plates of cast iron.

CASE No. 936

(*Interpretation of Par. P-112*)

Inquiry: Is it necessary that all small pipe connections which are welded under the requirements of Par. P-112 to piping be given Code inspection?

Reply: It is the opinion of the Committee that pipe connections up to $^1/_2$ in. pipe size may be welded under the requirements of Par. P-112 to piping without Code inspection.

CASE No. 937

(*Special Ruling*)

Inquiry: (*1*) Par. P-250(*a*) provides that a fire-tube boiler may have the ends of the tubes rolled, beaded, and welded.

May such tubes be rolled and welded without beading?

(2) Par. P-251 provides that a water-tube boiler may have the ends of the tubes rolled, flared, and welded in drums and headers. May such tubes be rolled and welded without flaring?

Reply: It is the opinion of the Committee that in addition to the requirements of Pars. P-250 and P-251, the following will meet the intent of the Code:

(1) Fire-tube boiler tube ends which are not subjected to direct radiant heat of the furnace may be rolled and seal-welded without beading provided:

(*a*) The tube ends do not extend less than $^1/_4$ in. nor more than $^5/_{16}$ in. beyond the tube sheet;

(*b*) The throat of the seal weld is not less than $^3/_{16}$ in. nor more than $^5/_{16}$ in.; and

(*c*) After welding the tubes are re-expanded.

(2) Water-tube boiler tubes may be rolled and seal-welded without flaring, provided the throat of the seal weld is not less than $^3/_{16}$ in. nor more than $^3/_8$ in.; and the tubes are re-expanded after welding.

CASE No. 938

(Special Ruling)

Inquiry: May tubes meeting the requirements of A.S.T.M. Specifications A179-40 be used in unfired pressure vessels built in accordance with the code?

Reply: It is the opinion of the Committee that A.S.T.M. Specifications A179-40 will comply with the requirements for tubes for unfired pressure vessels as a substitute for Specification S-17. Since A.S.T.M. Specifications A179-40 provides for both average wall and minimum wall tubes, it will be necessary to specify that tubes shall be furnished to minimum wall thickness.

CASE No. 939

(Special Ruling)

Inquiry: Is it intended to cover all details of construction in the several sections of the A.S.M.E. Boiler Construction Code?

Reply: The Code does not give rules to cover all details of design and construction. Where complete details are not given, it is intended that the manufacturer, subject to the approval of the authorized inspector, shall provide details of design and construction which will be as safe as otherwise provided by the rules in the Code.

CASE No. 940

(Special Ruling)

Inquiry: Is it permissible to use flat plate materials complying with A.S.T.M. Specifications A7 or A10 as manhole covers for unfired pressure vessels?

Reply: It is the opinion of the Committee that manhole covers formed of flat plate, on which no strength welding is applied, may be made of the above materials provided the operating temperature does not exceed 650 F.

CASE No. 941

(Special Ruling)

Inquiry: Is it permissible to construct welded unfired pressure vessels in accordance with Par. U-68, of high-tensile manganese molybdenum steel conforming to A.S.T.M. Specifications A204-38, modified as follows:

Carbon, max, per cent	0.22
Manganese, max, per cent	1.50
Phosphorus, max, per cent	0.04
Sulphur, max, per cent	0.04
Silicon, per cent	0.15–0.30
Molybdenum, per cent	0.40–0.70
Tensile strength, lb per sq in.	90,000–105,000
Yield point, min, lb per sq in.	55,000
Elongation, min, in 2 in., per cent	2,300,000 tens str

Reply: It is the opinion of the Committee that it is permissible to construct welded unfired pressure vessels of the steel specified in the inquiry under the provisions of Par. U-68 with the following additional provisions:

(1) The maximum thickness of shell or head shall be $^5/_8$ in.;

(2) The maximum allowable working stress shall be 18,000 lb per sq in.;

(3) The service temperature shall be that of the atmosphere;

(4) The material shall be preheated to not less than 170 F and held there throughout the welding operation;

(5) Weld reinforcement shall be removed;

(6) After stress relief the vessel shall be cooled slowly in the furnace to less than 600 F with the furnace doors closed;

(7) Welded test plates shall be made from the same lot of material, and receive the same heat-treatment as the vessel itself.

CASE No. 942

(Special Ruling)

Inquiry: May wrought-iron plates meeting the requirements of A.S.T.M. Specification A42-39 be used in the construction of Par. U-69 unfired pressure vessels?

Reply: It is the opinion of the Committee that this material will meet the intent of Par. U-71(*a*) and may be used for unfired pressure vessels with the following limitations:

(1) The plate shall be stamped with the maker's brand or name, the words "wrought iron," the minimum tensile strength of the specified range parallel and transverse to rolling, the lot number or test identification number;

(2) The design stress shall be not more than one fifth the minimum tensile strength of the material both parallel and transverse to the direction of rolling;

(3) The maximum metal temperature in operation shall not exceed 650 F.

Following is a record of the interpretations rendered in Cases Nos. 897 (Reopened), 943 to 946, formulated at a meeting of the Executive Committee of the Boiler Code Committee on August 12, 1941, and subsequently approved by the Council of The American Society of Mechanical Engineers.

CASE No. 897 (Reopened)

Revised item (7)

(7) *Allowable Working Stresses.* For Pars. U-68 and U-69 vessels the allowable working stresses shall be those given in Table U-2 for A.S.T.M. Specifications A167-39 until such time as they are replaced by stresses for A.S.T.M. Specifications A240-40T.

For Par. U-70 vessels the maximum allowable working stresses for steel complying with A.S.T.M. Specifications A240-40T shall be 25 per cent greater than those given in Par. U-70(*a*) and (*b*).

CASE No. 943

(Special Ruling)

Inquiry: Difficulties have been encountered in obtaining steel manufactured to Specification S-2 as provided in Par. P-186(*a*) for use in forge-welded Morison corrugated furnaces. Is it permissible under the Code to use firebox quality steel meeting the requirements of Specification S-1 when welded by the forging process?

Reply: It is the opinion of the Committee that firebox steel meeting the provisions of Specification S-1 may be used for the purpose stated in the inquiry provided the limitations in Specification S-2, Par. 3(*b*), for incidental nickel, chromium, and silicon are not exceeded. The thickness of plate shall be not less than that required for Specification S-2 material.

CASE No. 944

(In the hands of the Committee)

CASE No. 945

(Special Ruling)

Inquiry: Is it permissible under the Code to employ hot-rolled aluminum bronze of the composition and physical

properties given below for the tube sheets of heat exchangers:

Copper, per cent	76 to 84
Nickel, max, per cent	7
Iron, max, per cent	3.5
Aluminum, per cent	8 to 11
Manganese, max, per cent	2
Impurities, max, per cent	0.50
Tensile strength, min, lb per sq in	90,000
Yield point, min, lb per sq in.	36,000
Elongation in 2 in., min, per cent	10

Reply: It is the opinion of the Committee that it is permissible to employ the specified material for the tube sheets of heat exchangers under the following limitations:

(1) The working temperature shall not exceed 250 F.

(2) The working fiber stress shall not exceed 10,000 lb per sq in.;

(3) No welding shall be done on this material.

CASE NO. 946

(Interpretation of Pars. H-61 and H-114)

Inquiry: Pars. H-61 and H-114 of the Code require that "each steam boiler shall have one or more gage glasses." No doubt the word "glass" was used in these paragraphs because no other suitable material had been offered for this service when the Code was written. However, there is now available specially treated transparent plastic material with properties suitable for this service. May such material be used in place of glass in water gages on steam heating boilers?

Reply: It is the opinion of the Committee that any transparent material may be used for water gages provided it is suitable for service under the pressure, temperature, and corrosive conditions met in this service.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Flow of Water in Pipes and Pipe Fittings

√ FLOW OF WATER IN PIPES AND PIPE FITTINGS. By John Ripley Freeman, C.E. Published by The American Society of Mechanical Engineers, New York, N. Y. Leather, 9 × 11½ in., 349 pp., 196 figs., $8.

REVIEWED BY R. L. DAUGHERTY[1]

THIS excellent publication should become a classic in hydraulics comparable to "Lowell Hydraulic Experiments" of James B. Francis. It gives in great detail the results of an extensive series of experiments made by Mr. Freeman at Nashua, New Hampshire, in 1892, but which that busy man never found time to prepare for publication. However his notes were so complete and so comprehensive that his son, Clarke Freeman, assisted by Dr. Clifford P. Kittredge, Alton C. Chick, and George W. Young, was able to prepare this manuscript from them.

In so doing they recomputed and carefully checked all the values, and although Mr. Freeman had originally plotted his data using gallons per minute as a coordinate, he had fortunately taken frequent readings of the water temperature. This has enabled the editors to present the data in the modern form as functions of Reynolds' number.

The Blasius formula for friction factor in pipes was based upon the 1903 experiments of Saph and Schoder, which extended to a Reynolds number of about 100,000 as an upper limit. The Stanton and Pannell data of 1914 went to a Reynolds number of 400,000, but these 1892 tests of John R. Freeman extended to a Reynolds number as high as 900,000.

Tests to determine the pipe friction were made with five sizes of brass pipe ranging from ½ inch in diameter to 4 inches, thirteen sizes of new wrought-iron pipe ranging from ¼ inch in diameter to 8 inches, 4-inch and 8-inch new cast-iron pipe, as well as experiments with old rusty pipe and pipes containing two types of artificial roughness. These were followed by a series of tests of the friction loss in various pipe fittings arranged in a variety of ways relative to each other. Altogether it forms a most valuable collection of data of extreme usefulness to the engineering profession even at the present time.

A perusal of this volume reveals that Mr. Freeman had conducted these experiments with a great deal of care and that therefore the results may be considered as very accurate. Apparently he did not overlook a single source of error and took the proper steps either to avoid the error or else to determine it and make correction for it. The accuracy of his experimental technique was as high as that found in the best laboratory investigations of the present day.

This volume has been published by the John R. Freeman estate and it represents a valuable contribution to the engineering literature of our day.

[1] Professor of Mechanical Engineering, California Institute of Technology, Pasadena, Calif. Fellow A.S.M.E.

Applied Heat Transmission

APPLIED HEAT TRANSMISSION. By H. J. Stoever. McGraw-Hill Book Co., Inc., New York, 1941. Cloth, 6 × 9½ in., 226 pp., illus., $2.50.

REVIEWED BY L. M. K. BOELTER[2]

APPLIED Heat Transmission, by H. J. Stoever, is prepared in a style which the author hopes will be "particularly attractive to practicing engineers."

The first three chapters present information relative to the transfer of thermal energy by the modes of conduction, radiation, and convection applied to systems of simple geometry, invariable system parameters (except for two cases in which the linear thermal-conductivity-temperature relations are included), constant boundary conditions, and the unidimensional steady state (with the exception of the transient behavior of a slab).

Unit conductances (called convection coefficients) for free and forced convection in and across tubes and plates and based on empirical equations, are presented in a combination graphical and tabular form for handy computation. Unit conductances for boiling (at low temperature differences), for film condensation, and scale are also included.

[2] Professor of Mechanical Engineering, University of California, Berkeley, Calif. Mem. A.S.M.E.

Separate curves are presented for a number of fluids and solutions in both the liquid (34 in number) and the gaseous (28 in number) phase. Unfortunately, the literature sources of the properties of the substances employed to establish the curves are not given, nor are the ranges of system variables and parameters stated for which the empirical equations are adequate. The author notes that a conservative design will always be accomplished, however. A very important system technologically, the extended (finned) surface, has not been treated.

The discussion of radiation is limited to the steady-state energy interchange between surfaces of simple geometrical juxtaposition. Gaseous and luminous radiation are not treated. The reader does not seem to be adequately warned that the equivalent unit conductance for radiation (h_r) is a variable which behaves quite differently than the unit conductance for convection (h_c). Thus the sum ($h_r + h_c$) must be handled with caution. Chapter 5 presents charts and tables which will make possible the determination of pressure drop through and along straight tubes, also caused by sudden enlargements, sudden contractions, flow reversals, and density changes. Both the viscous and turbulent regimes are included, the fluids being in either the liquid or gaseous phase. Mention of the fact that free convection will affect the pressure drop through tubes in the viscous regime is omitted. The analytical results which are available for the viscous region (no free convection) and later experimental data in the turbulent region (J. F. D. Smith) have not been presented.

The last two chapters include descriptions of several types of heat exchangers and pipe insulation, respectively. In the last chapter the economics of insulation choice is discussed for the case of continuous operation. The important technological case of transient (intermittent) operation of pipe lines has not been discussed.

Summarizing curves are presented which when augmented by the accompanying tables will yield numerical magnitudes of unit conductances only for particular fluids in particular systems. The equations and curves are utilized in some well-chosen problems. The conductances are based on empirical expressions which are to a large extent presented elsewhere in texts and handbooks and which are subject to the interpretation of the experimental data by the original author, as well as the limitations of range of variables. In many cases the latest experimental and analytical information available in the literature has not been included. The book would not lend itself as a text in a course in heat transfer in which the application of basic principles to a variety of systems was the prime objective.

Books Received in Library

Accounting for Engineers. By J. R. Bangs and G. R. Hanselman. International Textbook Co., Scranton, Pa., 1941. Fabrikoid, 6 × 9½ in., 532 pp., illus., diagrams, charts, tables, $4. The subject material of this textbook, which is amplified by many diagrams, tables, and examples, is divided into five major sections: theory of debit and credit; procedure at end of fiscal period; accounting practice; accounting applications; and costs. The method of presentation permits the use of the book as a general text in basic accounting principles. Sample financial statements are appended.

ATM (Archiv für Technisches Messen), Lfg. 116, 117, 118, February, March, April, 1941. R. Oldenbourg, Munich and Berlin, Germany. Paper, 8½ × 12 in., pp. T16-30, F2; T31-46; T47-62; illus., diagrams, charts, tables, 1.50 rm each. Three numbers of a monthly publication containing classified articles upon various types of apparatus and methods for technical measurements. Some of the numbers also contain descriptions of specific instruments manufactured by German companies.

Amos Eaton, Scientist and Educator, 1776–1842. By E. M. McAllister. University of Pennsylvania Press, Philadelphia, Pa., 1941. Cloth, 6 × 9½ in., 587 pp., illus., $5. Amos Eaton, the founder, with the backing of Stephen Van Rensselaer, of what is now Rensselaer Polytechnic Institute, lived an eventful life. This exceedingly well-documented biography describes his early life, his ill-starred business and legal career, his noteworthy ventures into the natural sciences, particularly geology, and his final success as an educator.

Audels Machinists and Tool Makers Handy Book. By F. D. Graham. Theodore Audel & Co., New York, N. Y., 1941. Cloth, 5 × 7 in., section A, 1126 pp., section B, 98 pp., section C, 300 pp., section D, 42 pp., section E, 10 pp., illus., diagrams, charts, tables, $4. The purpose of this book is to provide a complete course of study for those desiring to become machinists and to help machinists become tool makers. In considering each machine, the author first explains how it works, then describes its construction, and finally gives detailed instructions for all machining operations. Blueprint reading, shop mathematics, and other useful topics are included. The book is profusely illustrated.

Audels New Electric Science Dictionary. By F. D. Graham. Theodore Audel & Co., New York, N. Y., 1933, reprinted 1939. Cloth, 5 × 7 in., 525 pp., $2. Over nine thousand words, terms, and phrases used in theoretical and applied electricity are defined in this dictionary. Numerous terms in related and independent subjects have been included to increase the utility of the work and extended explanations are given for the more important entries.

Automobile Industry, the Coming of Age of Capitalism's Favorite Child. By E. D. Kennedy. Reynal & Hitchcock, New York, N. Y., 1941. Cloth, 6 × 9 in., 333 pp., tables, $3.50. Once more the genesis, development, and current trends of the automobile industry are presented as a shining example of American industrial progress. Full of facts and figures, the separate chapters picture in strict chronological order the achievements and vicissitudes which have attended the making and selling of automobiles through the last five decades.

Better Foremanship. By G. Gardiner. Second edition. McGraw-Hill Book Co., Inc., New York, N. Y., 1941. Cloth, 5 × 8 in., 336 pp., tables, $2.50. In a direct, practical question-and-answer treatment this book presents modern industrial management for foremen. The subjects covered were chosen to give the foreman help both with fundamental functions and practices of foremanship and with the new problems resulting from recent changes in working conditions, labor relations, and industrial methods.

Descriptive Geometry. By A. S. Levens and H. C. T. Eggers. Harper & Brothers, New York, N. Y., and London, England, 1941. Cloth, 6 × 9½ in., 240 pp., illus., diagrams, charts, tables, $2.50. A full presentation of both graphic and algebraic methods of descriptive geometry provides a double check on solutions and achieves a correlation between descriptive and analytical geometry. In addition to the general coverage of fundamentals there is a long chapter on present-day practical applications in various technical fields.

Design of Manufacturing Enterprises, a Study in Applied Industrial Economics. By W. Rautenstrauch. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1941. Cloth, 6 × 9½ in., 298 pp., illus., diagrams, charts, tables $3.50. Profitable operation of large and small manufacturing businesses is dependent on their efficient economic design. This book makes available the principles and methods of the economics of manufacture taken from practical experience in the designing of new, or the redesigning of existing businesses for improved operating characteristics. The first part of the text deals with business as a whole; the second, with selected problems from both process and mechanical industries.

Development of the Sciences, Second series. By O. Ore, F. Schlesinger, and others, edited by L. L. Woodruff. Yale University Press, New Haven, Conn., 1941. Cloth, 6 × 9½ in., 336 pp., woodcuts, diagrams, $3. This second series of published lectures (the first series appeared in 1923) comprises discussions by eight Yale scientists representing the fields of mathematics, astronomy, chemistry, physics, geology, biology, psychology, and medicine. Each of the first seven lectures traces the development of basic sciences from their beginnings to the most recent results. The last lecture shows the interdependence of these various sciences as illustrated by specific examples in the history of medicine. The chapter bibliographies are brought together at the end of the book.

Directory of Microfilm Sources including photostat service, compiled by R. C. Cibella. Special Libraries Association, New York, N. Y., 1941. Paper, 7 × 10 in., 56 pp., diagrams, $0.75. The main section in this timely directory is an alphabetical list of more than two hundred libraries and commercial firms which offer microfilm, photograph, and photo-

stat services. Microfilm collections are also indicated, and a geographical index to the list is provided. The reproduction of sample order forms from many of these sources adds a practical touch.

ENGINEERS' MANUAL OF STATISTICAL METHODS. By L. E. Simon. John Wiley & Sons, Inc., New York, N. Y., 1941. Cloth, $6^1/_2 \times 10$ in., 231 pp., illus., diagrams, charts, tables, $2.75. This book is a summary of certain working parts of the sciences of probability, statistics, and logic, and is designed to assist the practical man in industrial or engineering work. Since the book is written primarily for use in an ordnance school for instruction in statistical techniques, the illustrative examples are generally taken from standard procedures or research at arsenals and proving grounds. The principles are, however, applicable to other inspection or quality-control problems.

FIRE-HAZARD PROPERTIES OF CERTAIN FLAMMABLE LIQUIDS, GASES, AND VOLATILE SOLIDS, compiled by Committee on Flammable Liquids of the National Fire Protection Association. Revised edition, 1941. National Fire Protection Association, Boston, Mass. Paper, 6×9 in., 48 pp., tables, $0.25. Over four hundred flammable liquids, gases, and volatile solids are included in the table of data compiled in this pamphlet. In addition to the information upon fire-hazard properties there is also a column indicating the proper extinguishing agent for each material.

FLIGHT, First Principles. By B. Wright, J. J. Smiley, and R. Martin. 283 pp. FLIGHT, Construction and Maintenance. By B. Wright, W. E. Dyer, and R. Martin. 259 pp. American Technical Society, Chicago, Ill., 1941. Cloth, $6 \times 9^1/_2$ in., illus., diagrams, charts, tables, $2.50 each. These two volumes present in a simple, practical manner the fundamentals of aviation and airplane manufacture. The book on first principles covers aerodynamics, soaring theory, and parachutes, and contains an illustrated glossary. The second volume deals with blueprint reading, airplane materials, construction methods, repair work, and propeller practice. A series of quiz questions with answers appears at the end of each book.

Fraser and Jones' MOTOR VEHICLES and Their Engines. By N. G. Shidle and T. A. Bissell with the assistance of T. Francis. Fifth edition. D. Van Nostrand Co., New York, N. Y., 1941. Cloth, 6×9 in., 339 pp., illus., diagrams, charts, tables, $2.50. This book is designed to give a clear knowledge of the theory of operation and maintenance of modern automobiles to beginning students. Current design and practice are emphasized, and for practical purposes most chapters contain information on likely troubles, their reasons and common remedies. The descriptive material is confined to examples from the passenger-car field, but a considerable portion of this and the whole final chapter are applicable to motor trucks.

GAS-LIFT PRINCIPLES AND PRACTICES. By S. F. Shaw. Gulf Publishing Co., Houston, Texas, 1939. Leather, $5^1/_2 \times 9$ in., 156 pp., illus., diagrams, charts, tables, $3. The first half of this book is devoted to the history, principles, and operation of gas-lift and its equipment, including a considerable amount of gas-lift performance data. The later chapters cover compressor-plant installations and examples of actual gas-lift practice in various fields both domestic and foreign.

DER INDUSTRIELLE WÄRMEÜBERGANG für Praxis und Studium mit grundlegenden Zahlenbeispielen. By A. Schack. Enlarged edition. Verlag Stahleisen, Düsseldorf, Germany, 1940. Cloth, $6^1/_2 \times 9^1/_2$ in., 348 pp., diagrams, charts, tables, 19.60 rm. This practical textbook for engineers is based upon investigations of the Verein deutschen Eisenhüttenleute. Radiation, convection, and conduction are discussed at length. The calculation of recuperators and regenerators is explained and the use of the theory of heat transmission is illustrated by numerous practical examples. A brief chapter on pressure loss in tubes and tube banks has been added in the new edition and the bibliography has been enlarged.

MANAGERIAL REVOLUTION, What Is Happening in the World. By J. Burnham. John Day Co., New York, N. Y., 1941. Cloth, $5^1/_2 \times 8^1/_2$ in., 285 pp., $2.50. The author submits the thesis that the running of the world is coming under the control of "managers," "managers" being defined as those who direct activities and do not come within either the capitalist-owner or the labor group. Reasons are advanced to show why the capitalist regime is doomed, and why socialism will not be the displacing system.

MATHEMATICAL TABLES. By H. B. Dwight. McGraw-Hill Book Co., Inc., New York, N. Y., 1941. Cloth, $6 \times 9^1/_2$ in., 231 pp., tables, $2.50. The values of both natural functions and logarithms of trigonometric functions are given to four or five places of decimals in hundreths of degrees rather than minutes and seconds. Exponential, hyperbolic, and other commonly used functions are also included. Tabular differences are included wherever desirable.

METAL PROCESSING. By O. W. Boston. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1941. Cloth, $6 \times 9^1/_2$ in., 630 pp., illus., diagrams, charts, tables, $5. This volume constitutes a revision of the author's "Engineering Shop Practice" consolidated with more recent data. All steps involved in designing for production are covered briefly in the first chapter: manufacturing drawing, analysis and form of material used, operations and equipment desired, and plant layout. Subsequent chapters treat in detail the various classes of machines and processes and other factors dependent upon conditions of quantity and quality. A bibliography accompanies each chapter.

PLANE FACTS FOR AIRPLANE AND ENGINE MECHANICS. By B. A. Kutakoff. Military Book Co., New York, N. Y., 1941. 241 pp., illus., diagrams, charts, tables, $1.75. This practical manual for airplane and engine mechanics presents the latest design and manufacturing practice in order to give an understanding of the structure of planes and engines. Maintenance and repair are also covered, and an extensive question and answer system facilitates review. The material conforms to Civil Aeronautics Administration regulations and practices.

PRINCIPLES OF MAGNAFLUX INSPECTION. By F. B. Doane. Magnaflux Corporation, Chicago, Ill., 1940. Cloth, $6 \times 9^1/_2$ in., 133 pp., illus., diagrams, charts, tables, $2.50. This description of magnaflux inspection methods covers equipment, processes, the inspection medium, detectable defects, demagnetization, and the evaluation of indications. There is a separate chapter on weld inspection. Basic physical principles are discussed briefly, and there is a bibliography.

RUNNING A MACHINE SHOP. By F. H. Colvin and F. A. Stanley. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1941. Cloth, $6 \times 9^1/_2$ in., 449 pp., illus., diagrams, charts, tables, $3.50. A practical manual which gives owners and managers of machine shops valuable pointers for more efficient and profitable operation. It covers everything from shop layout to inspection methods—equipment, routing and work handling, estimating, training of workers, and so forth. Methods and suggestions have been taken from the practice of leading shops of all types and sizes.

SAMPLING AND CHEMICAL ANALYSIS OF CAST FERROUS METALS. (Special Publication No. 7, March, 1941). By E. T. Austin. British Cast Iron Research Association Birmingham, England. Revised and enlarged edition. Linen, 6×10 in., 140 pp., diagrams, tables. This manual has been prepared for the use of chemists and metallurgists in works and other laboratories. Sampling procedure and general laboratory technique are described, and detailed directions are given for the analysis of pig iron, plain, malleable, and alloy cast irons, and ferro-alloys. Brief references to theory are included.

SURFACE TENSION AND THE SPREADING OF LIQUIDS. (Cambridge Physical Tracts.) By R. S. Burdon. University Press, Cambridge, England; The Macmillan Co., New York, N. Y., 1940. Paper, $5^1/_2 \times 8^1/_2$ in., 85 pp., illus., diagrams, charts, tables, $1.75. This latest addition to a series of authoritative accounts of topical physical subjects discusses the general conditions affecting the spreading of liquids, and gives some account of various investigations based on the phenomena of spreading. In the last chapter dealing with liquids on the surface of solids, certain technical aspects are considered.

TRAINING WORKERS AND SUPERVISORS. By C. Reitell. Ronald Press Co., New York, N. Y., 1941. Cloth, $5^1/_2 \times 8^1/_2$ in., 182 pp., tables, charts, $1.50. This volume of training procedures is designed for executives of plant organizations which are undergoing rapid expansion. The first part deals with the principles and methods for selecting men employees. The succeeding sections cover specific training methods for quality and quantity production and the problems of human relations. There is a list of selected references.

VDI-FORSCHUNGSHEFT 406. Elastische Formänderung und Lastverteilung beim Doppeleingriff gerader Stirnradzähne, by F. Karas. V.D.I. Verlag, Berlin, Germany, January-February, 1941. Paper, 8×12 in., 17 pp., diagrams, charts, tables, 5 rm; 4.50 rm to members. This research publication presents an analysis of tooth deflection and load distribution on the teeth of spur gears. The use of the results as a basis for profile correction is discussed.

WOHLER-INSTITUTS, BRAUNSCHWEIG, Mitteilungen, Heft 37. W. Bertram: Die Dauerhaltbarkeit von Gewinden bei verschiedenen Temperaturen und ihre Beeinflussung durch Oberflächendrücken. O. Föppl: Unter allseitigem Druck kalt geflossener Stahl. Aufhängung einer Verbrennungskraftmaschine in Gummi zum Zwecke der Verminderung der freien Massenkräfte. Friedrich Vieweg & Sohn, Braunschweig, Germany, 1940. Paper, $5^1/_2 \times 8^1/_2$ in., 74 pp., illus., diagrams, charts, tables, 4 rm. Three papers are presented in this contribution from a German technical institute: (1) Durability of screw threads at various temperatures and the influence of surface pressures upon durability; (2) tests of the cold flow of steel under pressure from all sides; (3) the suspension of a combustion engine on rubber for the purpose of decreasing the free mass energies.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

"Better Utilization of Coal" Theme of Joint A.S.M.E.-A.I.M.E. Fuels Conference

Easton, Pa., Oct. 30–Nov. 1

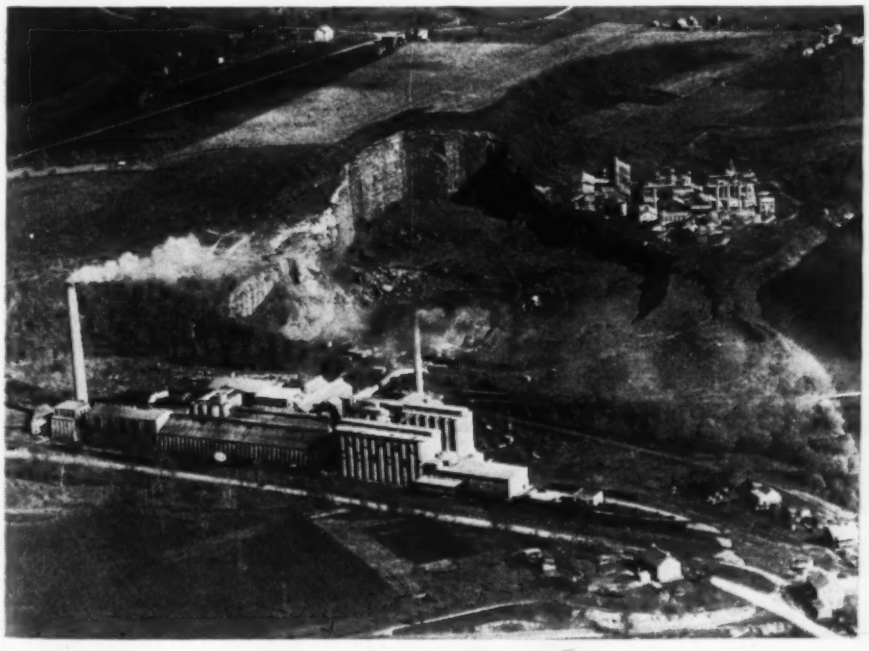
THE Fuels Division of the A.S.M.E. and the Coal Division of the A.I.M.E. are to hold their fifth annual meeting this fall at Easton, Pa., October 30 to November 1, with a program of papers and events all directed toward "Better Utilization of Coal." Headquarters will be at the Hotel Easton.

Welcoming Address by Dr. Lewis, President of Lafayette

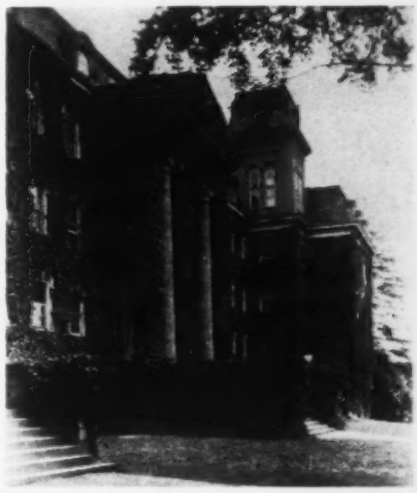
The meeting will open on Thursday morning with an address of welcome by Dr. William Mather Lewis, president of Lafayette College, with responses from William G. Christy for the A.S.M.E. and J. E. Tobey for the A.I.M.E. From there it will swing into a series of sessions with papers guaranteed to hold your interest. Indeed so great is the array of technical material that at first glance one would think that here was a meeting with all work and no play. That isn't so, for the Committee assures us that the lighter side of the menu is equally satisfactory. They even go so far as to say that there will be plenty of opportunities for golf—but you'll have to find them!

There will be a buffet luncheon at the Hotel Easton the first day of the meeting and that evening an informal dinner with Prof. Paul B. Eaton presiding, after which motion pictures will be shown of a study of anthracite combustion on small retorts.

The luncheon on Friday will be served in the gymnasium of Lafayette with entertainment by the Lafayette Singers. Prof. W. B. Plank will preside. The banquet of the meeting on Friday night in the Hotel Easton will certainly be a high spot, for the speaker will be E. G. Bailey who will take for his topic the theme of the meeting "Better Utilization of Coal." Motion pictures will be shown later of stoker-fired fuel beds by the Consolidated Edison Company of New York.



ALPHA CEMENT COMPANY PLANT TO WHICH TRIP IS PLANNED DURING A.S.M.E.-A.I.M.E. FUELS MEETING



"OLD SOUTH," 1833, LAFAYETTE COLLEGE

Inspection Trips

Four inspection trips have been planned, any or all of which will be found exceedingly well worth while. The first trip will include the two large cement plants about a twenty-minute drive from Easton, the Alpha Portland Cement Company (dry process) and the Lehigh Portland Cement Company (wet process).

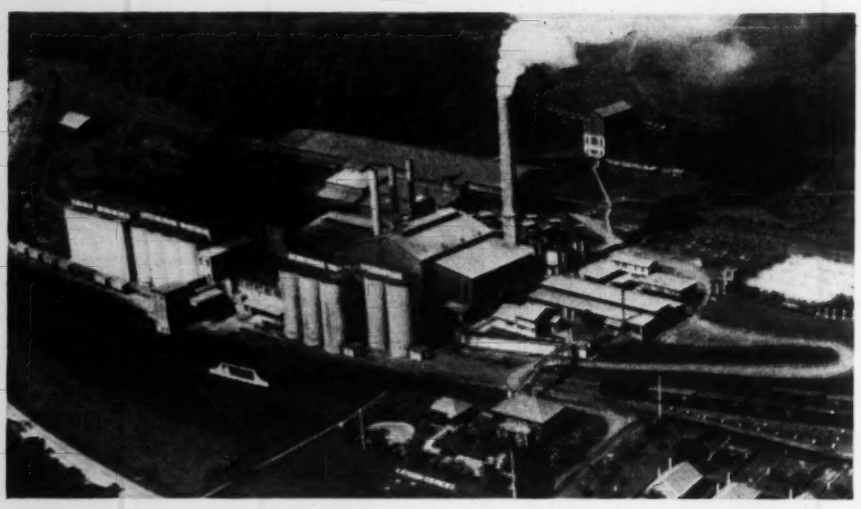
The second trip will be to the plant of the Riegel Paper Company with its pulverized-anthracite-fired boilers where an interesting process development is in progress. This plant is about a twenty-five minute drive from Easton.

The Lehigh Coal & Navigation Co. at Lansford, Pa., is the third trip and although it is farther away, about an hour and a half drive from Easton, it will well repay the time to see this anthracite mine and preparation plant. On this trip also a stop will be made at the Pennsylvania Power & Light Co., a pulverized-anthracite-fired plant.

The fourth trip will be to the Gilbert Station of the New Jersey Power & Light Co. where steam is generated at a pressure of 1350 psi at 760 F in a boiler fired with pulverized coal. The Station is about a half-hour drive from Easton.

If You Are Interested in Fuels, This Is Your Meeting!

As Mr. Christy reminds you in the little box on the next page, this is your real chance to attend fuels sessions since the Division is confining its Annual Meeting sessions to but one and putting its big effort into this meeting. The program is replete with interest and the committees in charge of affairs have really exerted every effort to make this fuels con-



LEHIGH CEMENT COMPANY PLANT TO WHICH TRIP IS PLANNED DURING A.S.M.E.-A.I.M.E. FUELS MEETING

ference an extremely valuable one. Plan to attend it—it will be worth your while!

Committees Do It

And speaking of committees, here they are: The chairmen of the two Divisions are William G. Christy, chairman for the A.S.M.E. Fuels Division and J. E. Tobey, chairman for the A.I.M.E. Coals Division. Working with them on the Local Arrangements Committee are Prof. Paul B. Eaton, chairman A.S.M.E., and Prof. W. B. Plank, chairman A.I.M.E. The program Committee is headed for the Mechanicals by A. W. Thorson and for the Miners by Henry F. Hebley.

Entertainment for the Ladies

The Ladies' Entertainment Committee is planning a series of luncheons and a drive through the famous Poconos for the ladies attending the Conference. No Conference is considered complete without the attendance of a large number of fair visitors. Be sure not to neglect this portion of your contribution to the success of the meeting.

Special Note!! Do not wait for the special literature detailing events and instructions. Make your room reservations now at the Hotel Easton and notify either: W. B. Plank or Paul B. Eaton of Lafayette College.

The detailed program follows:

Program

THURSDAY, OCTOBER 30

9:00 a.m.

Registration

9:30 a.m. Opening Session

Cochairmen: J. B. Morrow and A. W. Thorson

Address of Welcome, by Dr. William Mather Lewis, President of Lafayette College

Response by William G. Christy, chairman A.S.M.E. Fuels Division, and J. E. Tobey, chairman A.I.M.E. Coals Division

Application of Chemistry to Anthracite-Mine Fire Problems, by O. W. Jones and C. S. Scott, U. S. Bureau of Mines

Domestic Stoker Coal Research, by Walter Knox, research department, Koppers Company, and J. D. Doherty, research engineer, Koppers Coal Company

12:30 p.m.

Buffet Luncheon, Hotel Easton

2:00 p.m. Second Session

Cochairmen: J. E. Tobey and R. M. Hardgrove

Symposium on Adjustment of Pulverized-Fuel-Burning Equipment with contributions by Henry Kreisinger, Combustion Engineering Company; A. C. Foster, Foster-Wheeler Corporation; F. G. Ely, Babcock & Wilcox Co.; Ollison Craig, Riley Stoker Corporation

5:00 p.m.

Joint meeting of Executive Committees of the Coal Division, A.I.M.E., and the Fuels Division, A.S.M.E.

6:30 p.m.

Informal dinner at the Hotel Easton

Presiding: Paul B. Eaton

Motion Pictures Showing a Study of Anthracite Combustion on Small Retorts

8:00 p.m. Third Session

Cochairmen: J. E. Tobey and Martin A. Mayers

Symposium on Adjustment of Underfeed-Stoker-Fired Equipment with contributions by George P. Jackson, Combustion Engineering Company; J. S. Bennett, 3rd, American Engineering Company; R. A. Foresman, Westinghouse Electric & Manufacturing Co.

FRIDAY, OCTOBER 31

8:00 a.m.

Breakfast meeting of Model Smoke Law Committee, A.S.M.E. Fuels Division

Chairman: J. F. Barkley

9:30 a.m. Fourth Session

Cochairmen: David R. Mitchell and L. A. Shipman

Effects of Changes of Moisture and Temperature on Mine Roof, by I. Hartmann and H. B. Greenwald, U. S. Bureau of Mines Experiment Station, Pittsburgh, Pa.

Automatic Burning Control in Rotary Kilns, by W. E. Reaser, professor of mechanical engineering, Lafayette College

12:30 p.m.

Luncheon, Lafayette College Gymnasium

Presiding: William B. Plank

2:00 p.m. Fifth Session

Cochairmen: William G. Christy and Henry F. Hebley

The Performance of Industrial Chain-Grate Stokers, by J. H. Kerrick, Philadelphia and Reading Coal & Iron Co.

Burning Pulverized Anthracite on Steam Power Plants, C. H. Frick, plant-betterment engineer, Pennsylvania Power & Light Co.

6:30 p.m.

Banquet, Hotel Easton

Toastmaster: Howard N. Eavenson

Speaker: E. G. Bailey, vice-president, The Babcock & Wilcox Co.

Subject: "Better Utilization of Coal"

Motion pictures of stoker-fired fuel beds, by Consolidated Edison Company of New York

If Fuels Interest You!

Plan to Attend Fuels Meeting in Easton, Oct. 30–Nov. 1

AT a program conference held on May 16, it was the general tone of the meeting that the number of sessions for the A.S.M.E. 1941 Annual Meeting should be reduced. If this reduction is to be accomplished, it will require the cooperation of each one of the Professional Divisions of the Society. With this in mind, the Executive Committee of the Fuels Division agreed to have only one purely fuels session at the Annual Meeting.

We cordially invite all members interested in fuels to attend the Fuels Meeting in Easton, Pa., October 30 to November 1. This is the fifth annual fuels meeting sponsored jointly by the A.S.M.E. Fuels Division and the A.I.M.E. Coal Division. Several worth-while papers on mining, preparation and utilization of coal are on the program. There will also be two interesting symposiums—one on pulverized fuel and one on underfeed stokers. Inspection trips to cement plants, coal mine, coal-preparation plant, and power plants have been arranged.

Anyone interested in fuels should be well repaid for the time and effort spent in attending the Fuels Meeting at Easton.

WILLIAM G. CHRISTY, *Chairman*
Fuels Division, A.S.M.E.

SATURDAY, NOVEMBER 1

Inspection Trips

Trip No. 1

Alpha Portland Cement Co. (Dry process)
Lehigh Portland Cement Co. (Wet process)
About twenty minutes drive from Easton. Both plants may be visited on the one trip

Trip No. 2

Riegel Paper Co. Pulverized-anthracite-fired boilers. Interesting process development. About twenty five minutes drive from Easton

Trip No. 3

Lehigh Coal & Navigation Co., Lansford, Pa. Anthracite Mine and Preparation Plant. About one and one-half hours' drive from Easton

Pennsylvania Power & Light Co. Pulverized-anthracite-fired plant. Both plants may be visited on one trip

Trip No. 4

Gilbert Station, New Jersey Power & Light Co. Pulverized-coal firing 1350 psi, 760 F. About half hour's drive from Easton

Registration Fee for Non-Members at A.S.M.E. 1941 Fall Meeting

There will be a registration fee of $2 for nonmembers attending the 1941 A.S.M.E. Fall Meeting. For nonmembers wishing to attend just one session the fee will be $1. This is in accordance with the ruling of the Standing Committee on Meetings and Program.

Members wishing to bring nonmember guests may avoid this fee by writing to the Secretary of the Society before October 8 asking for a guest-attendance card for the Fall Meeting. The card, upon presentation by a guest, will be accepted in lieu of the registration fee. Guests are limited to *two per member*.

Last-Minute News on A.S.M.E. Fall Meeting at Louisville, October 12–15

Sessions, Trips, Inspection Tours, Dinners, Talks, Exhibits, and Entertainment Promise Four Memorable Days

COMPLETED plans for the A.S.M.E. Fall Meeting at Louisville, Oct. 12–15, promise to all in attendance an entertaining as well as instructive few days. No effort has been spared to make the technical sessions of interest to those in every branch of the profession. All members who have not signified their intention of attending by sending in the reservation card should do so immediately either through the card as provided, or directly to the Brown Hotel, convention headquarters. Everything has been done to make this a really "bang-up" meeting, according to Mr. Melvin Sack, chairman of the committee in charge of the meeting.

Industries of City Hosts for Trips

Two of Louisville's largest industries—the processing of tobacco and the distilling of liquors—will be hosts to the convention during plant trips which are scheduled during the meeting. Brown-Forman Distillery, makers of Old Forester and other famous liquors, will show their modern equipment and controlled warehouses. Axton-Fisher, where Spuds and Twenty-Grand are made, will illustrate the complete process of cigarette manufacture from leaf to package. A modern assembly plant and testing laboratory will be features of the trip to the American Air Filter Co. where engineers will see a demonstration of the modern electric filters which mark the last word in air purification. Louisville Gas & Electric Co.'s modern generating station will be of interest to all those who are connected with hydro and steam power.

Horse Show and Barbecue Dinner

Something unique will be added to the annals of A.S.M.E. history when the Louisville section stages the first horse show and barbeque dinner on the final day of the meeting. Crisp autumn air combined with sizzling barbeque meat and all the trimmings will wake up any dormant appetite. The Bluegrass' best thoroughbreds will form a pretty picture as they compete for honors. Officers of the Society will present the awards to the winners.

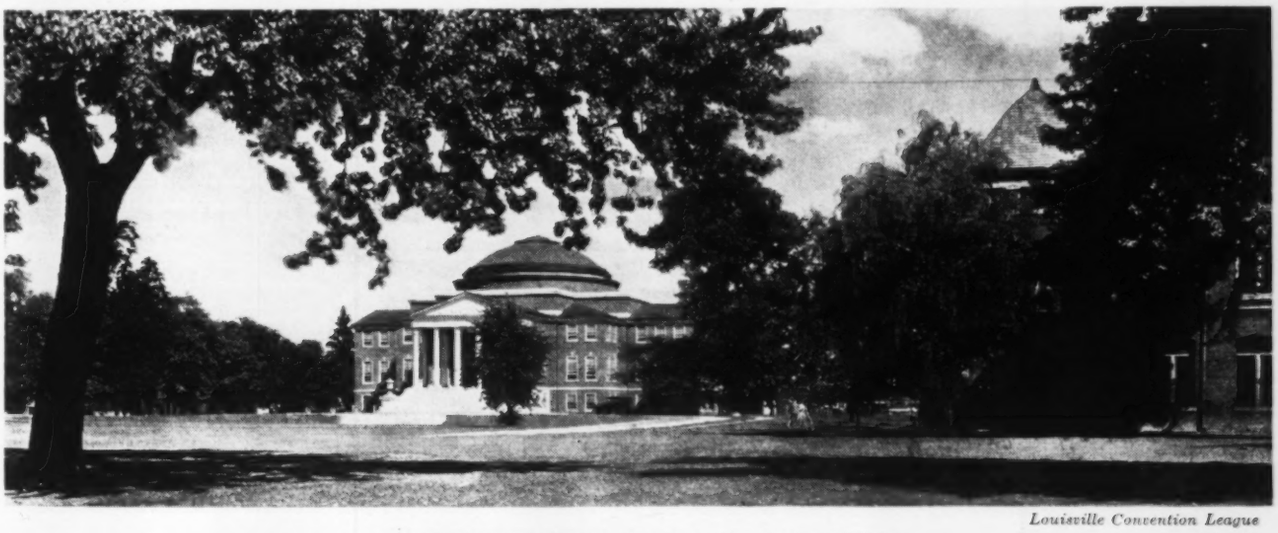
Don't Miss Mammoth Cave

All who attend the meeting are urged to complete their plans to make possible a visit to Mammoth Cave. On Thursday morning, October 16, the entire group will leave the hotel together and one especially reduced fee will take care of all expenses until return to the hotel, including lunch at the Cave. It promises to be a jolly crowd that tackles the famous "Fat Man's Misery" and the "Cork Screw."

Reduced Rates for Trips

The Local Committee on Arrangements has planned a strip ticket to sell for $8.50 to cover all luncheons, dinners, and plant trips. All tips are included in this price.

For Mammoth Cave a special price of $5 has been arranged which will include transportation to and from the cave in a Greyhound bus, a total of over 200 miles, luncheon at the



Louisville Convention League

ADMINISTRATION BUILDING, UNIVERSITY OF LOUISVILLE

LINCOLN SHRINE, HODGENVILLE, KY.

Mammoth Cave Hotel, and a 2½-hour trip through the caves. For those who drive their own cars the price will be $2.50.

The trip planned by the Ladies' Committee to the historic shrines of Kentucky will include a visit to The Old Kentucky Home at Bardstown, luncheon at a famous 100-year-old inn, a visit to the Lincoln Memorial at Hodgenville, where the log cabin in which the great emancipator was born has been preserved intact, a stop for a view of the Gold Depository and a tour through the Fort Knox Reservation. This trip will cost $2.

Walter White to Talk on "Free Enterprise and World Politics"

A talk by Walter White, U. S. Department of Commerce, on "Free Enterprise and World Politics" promises to be of national interest. The speaker for Monday's luncheon has not yet been announced, pending completion of last-minute plans by the entertainment committee with a prominent government figure. The Hon. Joseph D. Scholtz, Mayor of Louisville, will welcome the A.S.M.E. members and guests.

It has been specially stressed that the buffet supper to be served on Sunday the first day of the meeting, at 7 p.m. will be an ideal occasion to get acquainted with each other so that the remaining days of the meeting will seem even more friendly ones.

The Ordnance Display

In the September issue mention was made of the War Department display of Ordnance Matériel. This display will consist of mounted, sectioned, and loose items being sent from the Cincinnati Ordnance District.

There will be boards mounted with parts of unassembled artillery, bomb fuses, and boosters. Other boards will show progressive operations in the manufacture of shell, shell forgings, and cartridge cases. The entire display is planned to show problems in the manufacture of ordnance matériel and accordingly some of the items are sectioned to show the method of assembly and functioning.

In addition to the various sizes and kinds of shells and of cartridge cases, there will also be included antitank mines, spotting charges, hand grenades, bomb crates, tank tread, cartridge links and clips, signals, aircraft flares, and so forth.

Make Your Reservations

If you have not already done so, you are urged to send in immediately the reservation card which has been mailed to you. If you cannot locate this, write directly to the Brown Hotel, meeting headquarters in Louisville. *Do it now.*

Don't Let Him Leave You Home!

A Word to the Ladies

THE Bluegrass' reputation for hospitality will be at stake when the wives of A.S.M.E. members visit Louisville for the Fall Meeting, and it is surely our intention to uphold it. Not only have we planned sightseeing tours and other interesting events, but there will always be some of us around to get acquainted in an informal way. Besides the regularly scheduled events, we can get up some foursomes of bridge, and there'll be golf, too, at one of the Country Clubs for all who would like to play. We've tried to plan the following program so that there will be plenty of interesting things to do, and still allow time for rest, shopping, or other events.

Sunday

Registration
7 p.m., Buffet Supper

Monday noon, Luncheon with the Men

2:30 p.m., "Gateway to the South" Tour. A visit to the scenic and historic parts of Louisville

Tuesday, 9:30 a.m.

Trip to the historic shrines of Kentucky. Trip will include the Lincoln Shrine at Hodgenville, My Old Kentucky Home at Bardstown, and the Gold Vault at Fort Knox. Luncheon has been arranged at a famous 100-year-old inn

6:30 p.m.
Dinner

Wednesday, 2:30 p.m.

Horse Show and Barbecue. Something unusual. Louisville's finest thoroughbreds will compete for prizes to be offered by the Society. The barbecue dinner will be served at a riding club near the edge of the city

Thursday Morning

Trip to Mammoth Cave. An unusual privilege to see one of the seven wonders of the world at an especially reduced price

Remember—Don't Let Him Leave You Home!

Yours until October 12,
Mrs. Francis Shannon, *Chairman*
WOMEN'S COMMITTEE

1942 A.S.M.E. Mechanical Catalog and Directory Out

Over 500 Pages of Information

THE thirty-first annual A.S.M.E. Mechanical Catalog and Directory, 1942 edition, published October 1 by The American Society of Mechanical Engineers, will be distributed to members of the A.S.M.E. during October.

In its catalog section, manufacturers describe and illustrate their products that are of interest to mechanical engineers. This section is followed by a Directory which gives the user a practically complete and authoritative index to manufacturers of metals and alloys, powerplant equipment, power transmission equipment, instruments, materials-handling apparatus, aircraft power plants and instruments, foundry and machine-shop equipment, heating, ventilating, and air-conditioning equipment, electric motors and controls, equipment for process industries, pumps, fans, compressors, and many other types of mechanical apparatus. A page reference system in the Directory ties up with the catalogs providing descriptions of the desired machine or equipment.

According to the editors of the 1942 volume, it is the only book which covers the field of mechanical engineering so thoroughly.

A 16-page insert describing all A.S.M.E. publications, such as power test, boiler construction, and safety codes, American Standards, fluid meters, engineering biographies, bibliographies, research reports, and manuals, is included in this volume for the ready reference of A.S.M.E. members and other users.

News of the Calvin Rice Memorial Scholarship Recipients

WORD has been received from Mrs. J. Ansel Brooks, chairman of the Calvin Rice Memorial Scholarship Committee of the Woman's auxiliary to the A.S.M.E., concerning the recipients of that honor.

Eduardo R. Abril, the recipient of the Calvin Rice Scholarship for 1940–1941, has returned to his home in Argentina. He received his masters degree at the Massachusetts Institute of Technology. Mr. Abril said that he was taking home with him impressions which would be the most valuable in his life, and that he would always be grateful for this opportunity to study in the United States. He left the United States with the prospect of a position with the General Electric Company in South America.

A letter has been received from the Director General at the Pan-American Union expressing appreciation of the service the Woman's Auxiliary is rendering in furthering relations with South American countries. Also, a similar letter has been received from the chairman of the Council on National Defense.

Joao Hortencio de Medeiros is the recipient of the Calvin Rice Memorial Scholarship for the coming college year. He has received a tuition scholarship from Rensselaer Polytechnic Institute. The scholarship committee of the Institute of International Education and

the Calvin Rice Memorial Scholarship committee believe Mr. Medeiros is well prepared for advance study. He presented recommendations from several prominent men in Rio de Janeiro. He has been assistant engineer at the Marine Arsenal.

Rinaldo Radler de Aquiano, also a candidate for the Calvin Rice Memorial Scholarship award, has been given a scholarship at Rensselaer and a part-time teaching position in the department of aeronautical engineering. Mr. de Aquiano has been an apprentice aeronautical engineer with Panair do Brazil, a subsidiary of Pan-American Airways.

Up-to-the Minute Developments Will Vie With Fundamental Technical Papers at 1941 A.S.M.E. Annual Meeting

WITH practically every mechanical engineer up to his ears in work for the national defense, the task of preparing an acceptable program for the 1941 Annual Meeting of The American Society of Mechanical Engineers, to be held at the Hotel Astor, New York, N. Y., December 1–5, was tackled by the program-making agencies with the object of making it well worth while for busy men to attend.

Modern Production to Be Featured

Developments in the field of mechanical engineering, always numerous and important, are vastly accelerated in wartime. Not only may a new device become a decisive factor in ultimate victory, but the necessity of all-out production at maximum level demands immediate and widespread dissemination of new methods and techniques that create rapid obsolescence of today's practices. Although it is important that production proceed without interruption at a rapid pace, mechanical engineers cannot afford to pass up the chance of learning how to increase that production by spending a few days with their fellow experts instead of burying themselves too completely in the routine of practices that may already be obsolete.

The numerous changes that are taking place develop so rapidly that papers describing them, written in advance in accordance with A.S.M.E. procedure that was set up in more leisurely times with the object of providing preprints for discussion, are likely to be outdated when presented. Hence, it develops that in certain fields, particularly those of machine-shop practice and production techniques, the papers for the 1941 Annual Meeting may not be available until the hour of their presentation. Program-making agencies in these fields, therefore, have come to the conclusion that engineers and the nation will be better served by encouraging speakers to postpone preparation of their addresses until the last minute, rather than risk the possibility that new practices will be neglected. In adopting this procedure, members who are fortunate enough to be present at the Annual Meeting will benefit by hearing the "last word" on topics of vital interest, and those who are unable to attend will get more up-to-date information from the published reports.

Papers on Fundamental Technical Subjects to Be Preprinted

Not all of the 1941 Annual Meeting program will concern subjects in which developments are taking place so rapidly that postponement of the preparation of papers is necessary. A majority of the subjects to be discussed represent the more mature developments in established fields where progress has been steady and continuous. Reports of researches in the fields of the Society's activities, fundamental discussions of permanent value, typical of the best of A.S.M.E. literature of more than half a century, papers on matters that have been of primary concern to mechanical engineers for generations will make up the bulk of the program and will be available in preprint form as usual, so that well-studied discussion, frequently as valuable as the papers themselves, can be brought forth as in former years.

Program Being Developed

At the present moment it is impossible to present a detailed program of the coming meeting. The November issue will feature this information and announcements will be mailed to members as usual well in advance of December first. Program-making agencies are now engaged in selecting from the wealth of material available the papers that will be of greatest interest to members. The task of arranging a program of reasonable length and of avoiding the conflicts of too many simultaneous sessions is a difficult one. Year by year the number of professional divisions, technical committees, and joint agencies that seek to sponsor Annual Meeting sessions continues to grow. To the well-established groups that have provided the bulk of papers in the past, and whose activities have set the pattern of A.S.M.E. Annual Meetings, new ones have been added.

Strictly technical subjects as well as the customary addresses by eminent speakers are augmented by discussions of education and apprentice training, and by reports and papers on topics relating to ethics and other problems of the profession.

Nontechnical Events and Society Affairs

A.S.M.E. members do not need to be reminded that an Annual Meeting consists of many more features than a program of technical papers. Opportunity is afforded for plant-inspection trips, for meetings of Society committees, for social events, including a complete program for the women and the customary annual dinner, for the awarding of honors, for "college reunions," and for an art exhibit which this year will include not only photographs but also painting and sculpture by engineers.

Nor do old-timers need to be urged to attend for the sake of the privilege of meeting old friends and renewing acquaintanceships formed on previous occasions. What an Annual Meeting means in this respect is well known; and every year a growing number of younger men look forward to this valuable and personal feature of the week's activities.

Society affairs will, as usual, command the interest and attention of many. Meetings of the Council, of the Sections Delegates Conference, of the honorary chairmen and representatives of the Student Branches, and of many standing committees and boards will demand the presence of the engineers most actively engaged in forming and administering Society policies. For many years the total attendance at the A.S.M.E. Annual Meeting has exceeded 2000. Unless unforeseen circumstances develop, the 1941 registration should be the largest ever recorded.

1942 Membership List

November 1 Last Date for Correct Listing

CARDS have now been mailed to all members of the Society giving them an opportunity to supply correct information for the new Membership List to be issued in February, 1942. The cards also provide for listing in the Professional Service Index, a special section of the book for those engaged in professional engineering practice.

The cards must be returned by November 1 to insure correct listing. It must also be remembered that the directory will include only the names of those whose dues are paid in full by November 1 for the fiscal year beginning October 1, 1940.

Bigger Better Photographic Exhibit Planned for 1941 Annual Meeting

MEMBERS of the Society and their friends are invited to submit entries for the Sixth Annual A.S.M.E. Photographic Exhibit to be held as usual during the Annual Meeting of the Society, the first week in December in the Hotel Astor.

The Committee plans this year to make the Exhibit more "abundant" in that it will be expanded to include all forms of graphic art, such as etching, pencil drawing, lithography, water colors, oil paintings, sculpture, and so on ad infinitum.

Again this year handsome medals of gold, silver, and bronze will be awarded in all of the various classes. The best photographs based on subject and reproduction possibilities will be used in MECHANICAL ENGINEERING.

More complete details with final dates for the acceptance of entries will be given in the next issue. Watch for them!

Engineering Problems of National Defense Discussed at Three-Day A.S.M.E. Meeting, St. Louis, Sept. 9–11

"Streamlining" of Industry for National Defense

A SUCCESSFUL, well-planned, well-attended meeting devoted to the "streamlining" of industry for national defense was held at the Hotel Chase, St. Louis, Mo., Sept. 9–11, 1941, under the auspices of the National Defense Committee of The American Society of Mechanical Engineers and the A.S.M.E. St. Louis Section. Papers were read and discussed relating to tank manufacture, aviation, chemicals and explosives, plant protection, British and American defense methods, electric power, foundries, production machinery, fuels and lubricants, multiple production problems in shell manufacture, and relations of manufacturers with O.P.M. In a total of 11 technical sessions, three luncheons, and two dinner meetings, more than 30 technical papers and addresses were delivered.

Tank Manufacture

At the session on tank manufacture, with Maj. G. E. Mason, chief of the Procurement Service, St. Louis District Ordnance Office, presiding, Lieut-Col. Harold W. Rehm, commanding officer, Detroit Tank Arsenal, gave an informal talk on modern tanks, illustrated with motion pictures, and Frederick A. Stevenson, senior vice-president, American Car and Foundry Co., New York, told of his company's successful work in building light tanks and manufacturing armor plate for such military vehicles. Mr. Stevenson said that his company's talent and resourcefulness had established it as the sole source of light combat tanks for the army of the United States and those of its allies by building a total of 1500 units in a period of 16 months and had become the largest manufacturer of case-hardened armor plate in the world.

Mr. Stevenson reported that 500 light tanks manufactured by his company had been delivered to the British and had come through their "baptism of fire" with flying colors in both the Greek campaign and the current activities in the Near East. It had been stated, he said, that the British Government had approved the American type of tank as a first-class fighting unit on the basis of exhaustive tests in active service in Libya, under the same conditions that had wrecked the best designs which British manufacturers could produce. Fire power, speed, and freedom from repairs had been the outstanding features noticed.

Aviation

Speaking for the Army Air Corps, Brigadier-General George C. Kenney, Chief, Matériel Division, Wright Field, explained the difficulties of getting the aircraft industry of the nation into production under conditions of an ever-increasing program and rapidly changing technical developments in military aeronautics. He said that the best military airplanes in the world were being built in the United States, and answered many questions relating to planes used by the Axis powers, to maintenance of aircraft, and to engine types.

In reply to questions, General Kenney made clear the relative advantages of air-cooled and liquid-cooled engines for aircraft propulsion. Air-cooled engines, simpler than liquid-cooled, had been developed in this country for the needs of commercial planes for which long cruising at high speed, demanding a wide-open throttle, was not required. Under wide-open throttle, unit fuel consumption was higher in the air-cooled than in the liquid-cooled engine. Army use demanded long range and high speed and hence an engine economical at practically full throttle was demanded. Navy use called for shorter-range flights where the extra fuel consumption would not restrict either speed or range.

Contrary to some reports, he said, German engines and planes were made of excellent materials, were fully equipped with instruments, and exhibited the finest quality of workmanhip. Diesel engines were not being used by the Germans, although direct injection of fuel without carburetors had been adopted. Inasmuch as the fuel consumption of modern aircraft engines was already very low, little advantage could be gained by using the Diesel type, which suffered a greater hazard at very high altitudes than did the normal type.

Plastics applied to airplane structures were discussed by Charles E. Marschner, engineering department, McDonnell Aircraft Co., St. Louis, Mo. Mr. Marschner indicated briefly the portions of the airplane in which plastics had been used and might be employed, described the properties of a reinforced phenolic resin that was suitable for aircraft use, discussed problems of design and production, and the advantages and disadvantages of the material. He emphasized the fact that no all-plastic planes had been built, that plastics should be substituted for metals only as advantages warranted substitution and not as a way out of a material shortage, and answered questions relating to maintenance and temperature effects.

George Page, chief engineer, Curtiss-Wright Corp., St. Louis, Mo., presided at the Aviation Session.

At a luncheon on Sept. 9, David Larkin, general chairman of the St. Louis Committee, presided and, in the absence of Mayor William Dee Becker, former Governor Henry Caulfield delivered the address of welcome. Col. James L. Walsh, chairman, A.S.M.E. Committee on National Defense, spoke of the enormous magnitude of the problem of national defense, already costing the nation stupendous sums, and of the coming problem of civilian defense for which more expenditures would be necessary.

Plant Protection

Representatives of the Federal Bureau of Investigation and of the intelligence departments of the Army and Navy outlined problems and procedures facing manufacturers in protecting plants against sabotage. Lieut-Com. James K. Vardaman, Jr., officer in charge, Naval Intelligence Service, 9th Naval District, St. Louis, Mo., Dwight Brantley, of the Kansas City office of F.B.I., and Maj. H. G. Reynolds, of the office of the Under Secretary of War, chief of the Plant Protection Division, were the speakers. They cautioned all manufacturers of defense materials to be particularly careful about selecting personnel, urged fingerprinting of all employees, and emphasized the importance of fire and police protection. They pointed out that the responsibility for protection lay with management of plants and local authorities, and offered advice and, where proper, assistance of their branches of the government services.

It was made clear that all fingerprints taken of workers in plants were preserved in a civilian file and no possible objection could be raised against fingerprinting by honest citizens. It was also pointed out that campaigns to fingerprint employees were successful if properly conducted. Fingerprinting of executives set the example which resulted in 100 per cent coverage of employees.

Maj. Robert A. Bagnell, Ordnance Dept., U. S. Army, St. Louis, presided.

Chemicals and Explosives

At the session on chemicals and explosives H. E. Wiedemann, consulting chemist of St. Louis, presided, and the speakers were Robert R. Cole, vice-president and general manager, Phosphate Division, Monsanto Chemical Company, St. Louis, Lieut-Col. Geo. W. Carnachan, Chemical Warfare Service, Chemical Officer, Headquarters Sixth Corps Area, Chicago, Ill., and Dr. Jules Bebie, consulting chemical engineer, St. Louis.

Mr. Cole pointed out the importance of chemicals on the defense front, not only in the destruction of the enemy but in preserving morale and comfort, by means of medicinals, foods, raw materials, such as textile fibers, rubber chemicals and rubber substitutes, metals, plastics, fuels, and the like. Of the chemicals on the O.P.M. priorities list, he said, the situation with regard to nitrogen was the most serious. He reviewed also the situation regarding metals.

Lieut-Col. Carnachan spoke of the advantages of the use of gases in warfare for their effect on troops, for screening, and for incendiary

purposes. Toxic gases, up to now little used in the present war, might be resorted to if the war were to enter a stalemate phase. He also gave some indication of the relative effects of small incendiary bombs, heavy explosive bombs, and chemical gas bombs. He asserted that Germany was operating, in Poland, the world's largest war-gas factory.

Dr. Bebie's talk was a description of the use and manufacture of four types of explosives—initiators, such as detonators and primers, propellants, high explosives, and boosters—and of types of shells and their loading.

British Experiences

First-hand accounts of production methods and general conditions in England were presented by W. Stuart Symington, president, Emerson Electric Mfg. Co., St. Louis, and Wing Flight Commander H. D. Spreckley, R.A.F., at a buffet dinner on Tuesday evening at which Col. Harry Scullin, chief of the St. Louis Ordnance District, presided.

Mr. Symington described his impressions of England at war, including such factors as the serious-mindedness of the workers, the decentralization of production facilities and the reasons therefore, the use of underground plants, camouflaging and smoke screening, the large number of women in manufacturing plants, the abandonment of the three-shift for a two-shift program of production, and the high level of the spirit of the British.

Commander Spreckley reviewed the march of events in Europe preceding the war and the progress of the war up to the fall of France, and the effect that the catastrophe had had on the British. Attacks on London, he said, had destroyed many national monuments, but they had not destroyed the spirit of the people. He paid tribute to what this nation had done and was doing in supplying ships and aircraft. He spoke briefly of the effectiveness of the power-operated gun turret for fighting planes. England, he said, had been greatly improved by the war, in that the rich had learned how the poor lived and, through taxation, were contributing to social welfare.

Small-Arms Ammunition

Two papers on small-arms ammunition were presented at a session presided over by Lieut.-Col. Edwin B. Meissner, Ordnance Reserve, St. Louis. The speakers were B. E. Bassett, general manager, U. S. Cartridge Co., St. Louis, and Col. J. Kirk, chief small-arms ammunition, Frankford Arsenal, Philadelphia, Pa.

Mr. Bassett described plans and programs for the St. Louis ordnance plant that, when completed, will be the largest in the world, producing about half of the 50-caliber and one quarter of the 30-caliber small-arms ammunition for the defense program. The construction and operation of this plant, he said, was a tremendous project which would require wholehearted cooperation that would be a grave civic responsibility for St. Louis.

Mr. Bassett said that the plant had been located within the city limits of St. Louis because of the large number of employees that would be required and because of transportation difficulties. A training school had been set up and was in operation. Employees had been sent to the Frankford Arsenal to learn the procedures followed there that would be copied at St. Louis. These employees were being used in the training of new operators in the St. Louis training centers.

The size of the project, according to Mr. Bassett, had introduced serious problems in securing machinery and equipment. The small-tool program was enormous and had been tackled by subcontracting under a plan which established a tool depot in St. Louis from which tool steel was issued to subcontractors and to which completed tools were returned.

Colonel Kirk gave a detailed description of mass-production methods developed at Frankford Arsenal for the manufacture of small-arms ammunition. Methods used in all countries of the world had been studied and considered not to be good enough, and the methods developed at Frankford had been adopted by Russia, France, Great Britain, and Canada. Samples of the rounds in various stages of manufacture were on display.

Colonel Kirk said that the methods developed at Frankford Arsenal had increased production ten times in a year and a half, with increases also in quality. Frankford Arsenal had thus become the laboratory for manufacture of armor-piercing small-arms ammunition.

Foundries

At the session on foundries, Albert Vigne, president, Bronze Alloys Co., St. Louis, presided. In introducing the subject he spoke of some of the difficulties, now being ironed out, with specifications for nonferrous castings.

In a paper on cast-steel armor plate, H. M. Rishel, works manager, American Steel Foundries, Granite City, Ill., told how the steel foundries had been asked, in 1938, to develop cast armor plate and how they had formed a subcommittee for the exchange of information on developments. Advantages of cast armor plate were found in more compact design, in weight reduction owing to possibility of varying thickness, in facility of assembly because of fewer joints, in ability to cast rounded shapes, and in speeding up of assembly. Several steel foundries had developed acceptable cast armor plate.

Carl Morken, chief engineer, Carondelet Foundry Co., St. Louis, spoke about gray-iron castings in national defense. Most important uses were for machine tools, and for engines, compressors, pumps, and aircraft parts. Iron castings were being used as a substitute for heat-resistant and corrosion-resistant steels. Developments had been made in the control of cupolas and in special processes.

Speaking on steel castings, Claude Harrell, vice-president, Sterling Steel Castings, Monsanto, Ill., said that 75 per cent of present production was going into national defense. Typical applications were in bomb bodies and aircraft landing gears. Although the steel-casting industry had been stagnant for several years, defense requirements had been responsible for the development of new techniques that would make possible new peacetime uses.

Electric Power

Dr. William McClellan, president, Union Electric Company of Missouri, St. Louis, was the principal speaker at the Wednesday luncheon, at which David Larkin presided. Dean A. S. Langsdorf introduced Dr. McClellan, who painted a picture of the rapid increase of electric load resulting from growth of industrial activity and national-defense requirements. Every effort was being made to keep generating capacity ahead of requirements, but the time might come when power for nondefense might have to be curtailed.

Production Machinery

Eric Oberg, editor of *Machinery*, New York, N. Y., presided at a session devoted to production machinery, and paid tribute to the accomplishments of the machine-tool industry.

What enormous increase in demand for its product had meant to the machine-tool industry and how the demand was being met were emphasized dramatically by Tell Berna, general manager, National Machine Tool Builders' Association, Cleveland, Ohio. He showed how the industry had profited by experience and expansion of its facilities to meet demands by supplying European nations in advance of more recent requirements of our own defense program. Requirements for machine tools, he pointed out, had to be anticipated well in advance of national emergencies. He also estimated that a ten per cent increase in production, representing a ten per cent increase in machine-tool capacity, might be achieved by increasing morale of men in shops.

Honing processes and machines were described by A. M. Johnson, president, Barnes Drill Company, Rockford, Ill. Development of honing technique dated from 1925 and had been extensive. Vertical and horizontal machines were available and external as well as internal honing was being done successfully. A technical discussion of the honing process and finishes was presented by L. S. Martz, Micromatic Hone Corporation, Detroit, Mich. Both papers were illustrated with moving pictures showing typical honing operations and the motions of the hones.

Mr. Johnson quoted figures on the amount of stock removed by honing in several actual cases. The time required, he said, depended on the accuracy required and the amount of stock left by preceding operations, on the kind and hardness of the material, on the tolerance allowed, and on the fineness of the finish required. Generally, the honing process was not a difficult one, but at the beginning of a job considerable care had to be given to the proper speed, both rotary and reciprocating, to the intelligent choice of abrasive sticks, and to the best choice of coolant for the material being honed. If these conditions were satisfied reasonably well, he said, no trouble should be expressed in producing surfaces, both external and internal, conforming to close tolerances of size and finish.

President Hanley Speaks at Dinner

With David Larkin presiding, W. A. Hanley, President A.S.M.E., complimented the St. Louis Section on the success of the meeting and the excellence of the program and called on everyone to do his part in the national emergency. He was ably seconded in his attempts to emphasize the seriousness of the situation by Col. James L. Walsh.

Speaking on the Navy and national defense,

Capt. A. B. Anderson, U. S. Navy, Office of Naval Operations, Washington, D. C., paid tribute to the National Defense Committee of the A.S.M.E., on which he represents the Navy, and reviewed some of its activities. He said that the A.S.M.E. could be of great national service in doing all in its power to bring production to its peak at the earliest possible moment.

The strategic position of the Middle West in national defense was described by Lloyd C. Stark, former governor of Missouri. He pointed out reasons why that section of the country had been chosen as the location of defense plants, and spoke of the importance also of its agriculture in the Government's task of supplying Great Britain with food and developing its nutrition program at home.

Governor Stark told how a survey of the facilities of St. Louis had been made in order to determine its resources in men and manufacturing ability for the defense effort. As a result $750,000,000 of defense contracts had already been let in the area and many new plants and industries had resulted. There was even a possibility that certain kinds of shipbuilding might be undertaken. The Middle West's agricultural resources were also important in the winning of the war. The Middle West was well adapted to diversified farming. It afforded supplies of oil, coal, bauxite, iron, lead, zinc, and lumber. Several military camps, new and old, were located there. However, defense was not a regional but a national effort, and his references to the Middle West had been made to show what it had to offer and what it had contributed.

Colonel Kirk, Maj. Randall Hogan, Army Ordnance Department, and Ernest Hartford, executive assistant secretary A.S.M.E., also spoke briefly, and Albert Vigne, chairman of the A.S.M.E. St. Louis Section, was introduced.

Fuels and Lubricants

At a session on fuels and lubricants at which H. T. Ashton, general manager, Socony-Vacuum Oil Company, St. Louis, presided, C. M. Larson, consulting engineer, Sinclair Refining Co., New York, N. Y., spoke on the need for cooperative planning for greater utilization of fuels and lubricants in national-defense equipment.

Dr. Larson gave an over-all picture of the task of supplying the services with fuels and lubricants, and described steps being taken to reduce the number of grades of each. He spoke briefly of problems of transporting supplies and of packaging, and gave an intensely interesting account of his observations of the recent Third Army maneuvers in Louisiana in relation to lubrication and maintenance.

High lights of Dr. Larson's observations of the Third Army maneuvers in Louisiana included: The problem of identifying lubricating oils and greases in servicing mechanized equipment in a blackout. Oil-filter changes of 2500 to 5000 miles are too high; a change period of 500 miles is necessary in some dry dusty areas. Air cleaners for motorcycles generally need cleaning every day in dusty country. Of all lubrication failures that caused by ineffective oil seals of transfer cases and front differentials was most pronounced. The next in lubrication failure was the wick-fed generator bearing, generally on the commutator side. Some of the field forces feel that the lubrication charts developed by the Ordnance Department are too wide in scope for operations and should be reduced to those climate or temperature ranges of the particular maneuver or combat area in which the motorized equipment is operating.

Mr. Ashton presented a brief picture of the petroleum condition throughout the world with special reference to the Axis powers.

He said that the 1938 demands of "Hitler's" Europe had been 200 million barrels of which 75 million barrels had been produced in those countries. It had been Hitler's hope to use oil efficiently in a short war and to seize more supplies. Germany had attempted to make itself self-sufficient in petroleum, but this had been found to be impossible. Before the war there had been about 25 synthetic-oil plants in Germany. Today there might be twice that number. The product of the synthetic-oil plant was satisfactory for making gasoline and Diesel fuel but provided an inferior lubricant. Germany had no 100-octane gasoline.

He reviewed also the possible supplies of oil and the sources of supply in Roumania, Italy, and Japan. The Russian campaign, he thought, might have been undertaken in the quest for oil. By 1943, he prophesied, without further military drain and by holding industrial use to a minimum, Germany will have run out of oil. On the other hand, practically the entire world's reserve of petroleum existed in the Caribbean basin and the Near East, of which a major portion was in the possession of the United States.

Shell Manufacture

Maj. Randall Hogan, executive officer, St. Louis Ordnance District, presided at the session on shell manufacture at which J. H. Loux, Salem Engineering Co., Salem, Ohio, described the Witter rolling process for the rapid production of shell forging. Claude A. Witter, inventor of the process, was present to answer questions.

In the Witter process, billet steel is properly upset, forged, or pressed to form the pierced blank. This blank is conveyed to a loading station of the finishing mill where it enters the breakdown pass of the humped rolls with a smoothly machined mandrel inserted in the cavity of the pierced blank. The mandrel is kept bottomed in the blank by pressure from a pushing cylinder during the breakdown, elongating, and cross-rolling operations. On elongating, the metal wraps tightly on the mandrel as it passes through the humped rolls, thus producing a smooth and uniform cavity in the shell forging. After leaving the rolls, the forging is sized with mandrel still inserted and then the mandrel is automatically stripped, leaving the shell forging completed and ready for machining operations elsewhere. Ten or more mandrels are continuously in use in the automatic cycle and are properly cooled, thus assuring uniform production of shell forgings.

Some remarkable motion pictures in color were presented by R. T. Crocombe and B. Grakaw of the American Forging Division, American Brake Shoe and Foundry Co., Chicago, Ill., illustrating an upset process of shell forging.

Transportation Luncheon

At the luncheon on Thursday David Larkin introduced Capt. A. B. Anderson, U. S. Navy, Washington, D. C., who acted as presiding officer. Captain Anderson said that all vessels of every type used by the Navy were equipped with Diesel engines for one purpose or another.

Speaking on transportation at sea, Edward D. Pollister, president, Busch-Sulzer Bros. Diesel Engine Co., St. Louis, said that cast iron had been given up as a material for engine frames because of the effect of bombs exploding in water adjacent to the ship. Welded structural-steel frames had been substituted. He also spoke briefly of the difficulties involved in the manufacture of antiaircraft guns.

Col. John Henry Smith of the British Army and technical adviser of the British Purchasing Commission, Ottawa, Canada, praised the cooperation he had received from truck manufacturers in this country. He gave, at Captain Anderson's request, a moving recital of his experiences in the evacuation of Dunkerque.

Office of Production Management

The concluding session was devoted to work and functions of the Office of Production Management with particular reference to subcontracting, priorities, and problems of nondefense industries. The presiding officer was Harry B. Wallace, coordinator, O.P.M., St. Louis, and the speakers were Lieut-Col. H. Carter Bliss, Ordnance Reserve (who also read a paper by Frank C. McDevitt, District Manager, O.P.M., St. Louis), and L. E. Crandall, Manager, Priorities Division, O.P.M., St. Louis.

Local Committees Commended

The large and representative attendance at the St. Louis meeting and the fact that in times of a great national emergency when every mechanical engineer and military officer were constantly engaged in pressing duties of production they were willing to participate in programs testified to the importance of the subjects under discussion and the energy of the committee in arranging the sessions.

In addition to the A.S.M.E. Committee on National Defense of which Col. James L. Walsh is chairman, committees composed of members of the A.S.M.E. St. Louis Section were responsible for the arrangement of the program and its successful execution. The executive committee consisted of Albert Vigne, honorary chairman; David Larkin, chairman; Walter Siegerist, vice-chairman; Conway B. Briscoe, secretary; Robert M. Boyles, chairman finance committee; Donald E. Dickey, chairman program committee; Charles J. Colley, chairman arrangements committee; Arthur L. Heintze, chairman reception committee; and Richard W. Merkle, Robert C. Thumser, Herbert Kuenzel, and Herbert W. Hempel of the A.S.M.E. St. Louis Section.

On the general committee served A. S. Langsdorf, Col. James L. Walsh, Col. Harry Scullin, Maj. Randall Hogan, Lieut-Col. Edwin B. Meissner, H. B. Wallace, Frank McDevitt, Col. H. Carter Bliss, Elmer Donnel, Thos. Dysart, C. W. France, John W. Lawler, Wm. McClellan, F. W. Olin, H. Niedringhaus, Edgar Queeny, Fred Rein, W. Stuart Symington, A. H. Timmerman, and Adelbert von Gontard.

The Engineering Division of the National Research Council Transfers to Washington, D. C.

Brief Outline of Its History and Present Activities

THE general concentration in Washington, D. C., of the direction of war effort has led to the transfer of the office of the Division of Engineering and Industrial Research of the National Research Council from New York City to the National Capital. To those who may not be familiar with the organization and function of this unit in the complex of our war effort, a brief outline of its history and present activities may be of interest.

National Research Council Organized in 1917

In 1916 President Wilson addressed to the National Academy of Sciences an executive order directing the organization of a body of scientists and technologists for the special purpose of effecting a general mobilization of scientific and technical talent throughout the country, with reference to the effective study of problems of war and national defense. In accordance with this order the Academy proceeded with the organization of a body known as the National Research Council operating under the aegis of the Academy but organized to call to the aid of the Government for the study of the problems of war any scientist or technologist who might presumably give effective service with reference to such problems. The Council, thus created, was organized for active service in the spring of 1917, following our entry into World War I. It comprised divisions of engineering, physics, medicine and related sciences, geology and geography, chemistry and chemical technology, and a military division. These units were very active during the years 1916–1918 in the organization and in the study of a wide variety of problems of war and national defense.

With the close of our participation in the war effort, following the armistice in November of 1918, the demands for the study of war problems became less pressing and the activities of the Division of Engineering and Industrial Research turned in greater degree along lines of industry and industrial technology. With the purpose of facilitating contact with engineers and industry, the office of the Division was accordingly set up in New York in the Engineering Societies Building, headquarters of the great national engineering societies and in convenient contact with many centers of direction of great industrial activities.

The work of the Division during the period covering the time since World War I has been notable and effective, but with the supreme effort which we are now called on to make in connection with war preparedness and war aid to other nations, it has seemed wise to transfer to Washington the office of the Division, thus greatly facilitating physical contact with the direction of the war effort now centered in the National Capital.

Accordingly, as of July 1, 1941, the office of the Division was transferred to Washington where it is quartered in the building of the National Academy of Sciences. In the meantime the office in New York is being continued for such period as may be needed for the closing out of certain activities which may be more conveniently handled from that center.

Present Organization of Division of Engineering and Industrial Research

The present organization of the Division comprises a chairman, Dr. W. F. Durand, past-president A.S.M.E., and an executive secretary, Dr. W. H. Kenerson, Fellow A.S.M.E., with the necessary clerical and secretarial assistance. The Division comprises twenty-seven members of which nine are members of the National Academy of Sciences and represent that body, nine represent the various national engineering societies of the country, and nine are appointed at large.

The function of the Division, as derived from its relation to the National Academy and as seen by its executive staff, is to stand as a clearing house of information between the war effort now centered in the Departments of War and Navy and in certain recently created organizations, and the vast reservoir of potential information and service comprised in the engineering and industrial world of the United States, and as represented in first order by the national engineering societies with headquarters for the most part in New York City. It is also active in the organization of special committees for the study of matters related to our war effort, and in finding qualified experts for the study of special phases of war problems. Its officers and members also have membership on various committees and organizations having relation in one way or another to various phases of our war effort.

Work of the Division

Since the particular problems in the line of war effort on which the Division is at present engaged are necessarily of a confidential character, specific details cannot be given. However, the following will serve to give some general idea of its activities since July 1 last.

As indicated in the foregoing, the work of the Division falls into four main categories:

(1) The organization of special research projects.
(2) Setting up committees to study and report on certain definite problems.
(3) Sponsoring research organizations.
(4) Representation on committees in cooperation with other organizations.

As an example of the first type, a study is now in progress on a problem in aeronautic engineering of special interest to both the Army and the Navy. At the request of the National Research Council a committee of the Society of Automotive Engineers first prepared a report containing a statement of the problem, suggestions as to procedure, and a bibliography. An experienced engineer is now collecting and coordinating data and, in cooperation with industrial experts together with representatives of the Army and Navy, is carrying forward a program which gives promise of successful results.

Again, a second problem of great importance to the Navy, in the general field of metallurgy, has been made the subject of direct inquiry from the Washington office. A preliminary report on this subject has recently been made.

Committees of the National Research Council dealing with many subjects are active. For example, the "Conference on Electrical Insulation," consisting of about seventy members and two hundred associate members, and the "Committee on Heat Transmission" with its numerous subcommittees are doing much valuable work. As a result of the last-named committee an important publication on "Heat Insulation" will soon go to press.

Among other committees very active at the present time is one dealing with metallurgical research and another with welding.

Two important and active organizations functioning under the sponsorship of the Division of Engineering and Industrial Research are the Highway Research Board and the Industrial Research Institute.

The Highway Research Board draws representation from some thirty member organizations and is organized in seven departments with more than seventy projects and special committees. Its annually published proceedings is a veritable encyclopedia on highway transportation. The latest volume contains nearly nine hundred pages and more than fifty scientific and technical papers. Such papers are presented at the annual meeting when from 500 to 600 representatives from all parts of the country assemble for discussion and for exchange of information.

The Industrial Research Institute is organized to encourage through the cooperative effort of its members the use of the best possible research management techniques in American business and industry. At present some thirty-four member-companies, widely representative of industry and of industrial areas, are members of the Institute. Three or four meetings are held each year at which common problems are discussed in informal round table conferences.

Members of the Division are active through membership on committees in many defense activities centered in the nation's capitol. The establishment of the Washington office appears timely and requests now being received indicate continually increasing opportunities for the activities of this important division of the National Research Council.

1941 Local Sections Group Conferences

Group	City	Place	Date	In charge of	Presiding officer
I	New London	Mohican Hotel	Nov. 1	A. W. Luce	A. D. Andriola
II	New York	A.S.M.E. Headquarters	Oct. 1	F. D. Carvin	A. R. Mumford
III	Rochester	Univ. Rochester	Oct. 25–26	I. S. Bradley	J. S. Morehouse
IV	Winston-Salem, N. C.	Robt. E. Lee Hotel	Oct. 25–26	R. W. Olive	F. C. Smith
V	Detroit	Dearborn Inn	Oct. 18-19	A. M. Selvey	C. T. Oergel
VI	Louisville	Brown Hotel	Oct. 12	Wm. F. Lucas	R. A. Cross
VII	San Francisco	Clift Hotel	Oct. 25–26	H. T. Avery	A. D. Hughes
VIII	Dallas	Baker Hotel	Oct. 25–26	F. C. Justice	C. W. Crawford

TIME: 9:30 a.m. for all conferences except for Group II which will be 4:30 p.m.

California Local Sections of A.S.M.E. Carry on Meetings Throughout Summer

Los Angeles Section Visits Newspaper, Aircraft, Packing, and Wood-Products Plants and Holds Meetings; San Francisco Section Discusses Production Bottlenecks at Symposium

SO much enthusiasm was shown by the A.S.M.E. members of Los Angeles and San Francisco Sections in last year's summer programs of meetings and inspection trips, that they were again repeated this year. On June 26, the Los Angeles Juniors arranged an inspection trip through the plant of the *Los Angeles Examiner*. Of particular interest to the mechanical engineers were the photo-engraving processes, linotypes, and color presses.

Two-Day Meeting in San Diego

Several-score Los Angeles engineers availed themselves of the two-day meeting and inspection trips held in San Diego, July 11 and 12. At the dinner on Friday evening, the speakers were Major Ed. N. Gott, vice-president in charge of public relations, Consolidated Aircraft Corporation; George Tharratt, aircraft production engineer, Douglas Aircraft Company; and William Reeser, recipient of the A.S.M.E. Spirit of St. Louis Junior Award of 1941. On Saturday, inspection trips were made to the Consolidated Aircraft Corporation, Westgate Sea Products Company (packing plant), and Benson Lumber Company (wood mill).

The 1941-1942 year of meeting was opened on Aug. 14 by Los Angeles Section with two fine papers. The first, "Mechanics With Finesse," by Homer Tasker, assistant director of recording, Paramount Pictures, Inc., was a discussion of some of the highly specialized mechanical problems within the motion-picture industry. The second in keeping with the times was entitled, "The Nature of Economic Invasion," and was given by Prof. Graham Allan Laing, California Institute of Technology.

Production Symposium

"Bursting the Bottleneck in Production" was the title of the symposium arranged on May 22 by the San Francisco Section. This joint Senior-Junior meeting gave a description of the role production in machine shops plays in National Defense. Bert Truett, Junior A.S.M.E., presided. The speakers included Walter Kassebohn, plant manager, Autometric Machine Tool Co., and Harold T. Avery, chief engineer, Marchant Calculating Machine Co., and the new chairman of the Section.

Engineering Examiners to Meet in New York

REPRESENTATIVES of 40 state boards for registration of engineers are to meet at the Hotel Pennsylvania, New York, Oct. 27–30 for the 22nd annual meeting of the National Council of State Boards of Engineering Examiners. This is expected to be one of the most important meetings in the history of the Council as it is to be held in connection with the annual meeting of the Engineers' Council for Professional Development. Participating in the discussions will be representatives of the Dominion Council of Professional Engineers of Canada and representatives of the national engineering societies of this country.

Questions of growing importance such as reciprocal registration between the states and national registration are to be discussed at the business meetings. The effect of registration on the engineering profession is to be considered at a luncheon meeting held at the Engineers Club in which members of the Engineers' Council for Professional Development and the headquarters staffs of the national engineering societies will participate.

Defense questions are not to be overlooked at the meeting. Mayor LaGuardia of New York, U. S. Director of Civilian Defense, is to be the principal speaker at the annual banquet.

Stove Manufacturers Sponsor Research Program

TWENTY-SIX leading manufacturers of stoves have joined with Bituminous Coal Research, Inc., in sponsoring an enlarged research program to develop improved coal-fired heaters and kitchen ranges, according to an announcement by Battelle Memorial Institute, Columbus, Ohio, where the research is already in progress.

The arrangements were made by Bituminous Coal Research, Inc., with the cooperation of the Solid Fuel Division, Institute of Cooking and Heating Appliance Manufacturers.

The objectives of the research are stoves for use with bituminous coal that will burn both high- and low-volatile coals without smoke, that will automatically regulate the rate of burning, and that will have fuel capacity for 12 to 24 hours of operation at rated output.

A.S.M.E. Calendar

of Coming Meetings

October 12–15, 1941
Fall Meeting
Louisville, Ky.

October 30–November 1, 1941
Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions
Lafayette College
Easton, Pa.

December 1–5, 1941
Annual Meeting
New York, N. Y.

March 23–25, 1942
Spring Meeting
Houston, Texas

June 8–10, 1942
Semi-Annual Meeting
Cleveland, Ohio

June 9–11, 1942
Oil and Gas Power Division
Peoria, Ill.

(For coming meetings of other organizations see page 30 of the advertising section of this issue)

CALTECH GROUP THAT SPONSORED THE 1941 PACIFIC SOUTHWEST STUDENT MEETING

Thousands of A.S.M.E. Student Members Start 1941-1942 Year of Meetings

Yale Branch Gives Outline of Successful Program Held Last Year as Example to Other Branches

WITH thousands of A.S.M.E. student members going back to school and again taking part in the activities of their respective Student Branches, questions arise as to the type of programs to be held. Paul N. Strobell, 1940-1941 secretary of the Yale Student Branch, submitted an outline of the program, which proved so successful last year, for the consideration of other groups.

The meetings at Yale take the place of a senior seminar and are conducted under the direction of Dean S. W. Dudley, honorary chairman. The group meets once a week for a period of an hour and a half, during which all business of the Branch is handled and talks are given either by outside speakers or by students. The papers by the student members may be on topics of general interest and of a technical nature, emphasis being placed upon the contents, method of preparation, and effective presentation. Criticisms offered by the other student members are typed and given to the speaker the following week. Frequently throughout the year, when outside speakers are invited, other engineering groups join the A.S.M.E. student members.

Once each year a joint meeting is held with the New Haven Section of the Society. All preparation for this meeting is made by the Yale Student Branch, including the choice of a speaker for the evening, who is preceded by student speakers.

Annual Engineering Exhibition

An annual event in recent years at Yale University has been the Engineering Exhibition in which all departments of the engineering school participate in presenting their work to the general public. All equipment and machinery in the various laboratories are put into operation. The mechanical-engineering students handle all preparations for their exhibition through the Student Branch. Plans are made by the seniors and carried out by all student members. The exhibition lasts two days and is usually well received by the local people and high-school students.

One week during the year is devoted to an extensive inspection trip through the eastern part of the United States. This program is handled by Prof. H. L. Seward, who makes all arrangements and accompanies the seniors. Last year, concerns in and about New York, Philadelphia, and Pittsburgh were visited.

The Program

The program for last year consisted of the following events:

Sept. 24—Organization meeting and election of officers
Oct. 1—Discussion of activities and tentative program
Oct. 8, 15, and 22—Student papers
Oct. 29—A. L. Ruiz, General Electric Co.
Nov. 5, 12, and 26—Student papers
Nov. 19—Perry Borden, The Bristol Company
Dec. 3—Annual Meeting of the A.S.M.E., New York
Dec. 5 and 12—Joint meetings with A.S.C.E. Student Chapter
Dec. 10—Report on A.S.M.E. Annual Meeting
Dec. 17—Walter L. Tann, Farrell-Birmingham Co.
Jan. 7—Joint meeting with A.I.E.E. Student Group
Jan. 14—R. Carter Nyman, personnel director, Yale University
Jan. 21 and 28—Student papers
Feb. 4—S. B. Terry, Pratt & Whitney Division
Feb. 11—Student papers
Feb. 18—Joint meeting with New Haven Section of A.S.M.E.—Rudolph A. Gagg, Wright Aeronautical Corp.
Feb. 25—Discussion of Feb. 18 meeting
Mar. 1 and 2—Sixth Annual Engineering Exhibition
Mar. 4—Dwight Phelps, vice-president, Colt Patent Fire Arms Company
Mar. 10–15—Extended inspection trip to New York, Philadelphia, and Pittsburgh
Apr. 1—Discussion of inspection trip
Apr. 8—Grover Loening, consulting aeronautical engineer
Apr. 15 and 22—Student papers
Apr. 29—Joint meeting with A.I.E.E. Student Group
May 2 and 3—Annual Regional Conference of A.S.M.E. Student Branches
May 6—Discussion hour
May 13—Closing business meeting

Students Are Honored by Branches in May for Leadership

The American Society of Mechanical Engineers each year gives a biography of a famous engineer to every Student Branch for presentation at the end of the year to the student member who has done most for his organization. During the spring of 1941, copies of the biography of James Hartness, compiled by Joseph W. Roe, professor-emeritus of New York University, were awarded to the following by their respective Student Branches:

Brooklyn Poly—John A. Lawrence; Bucknell—Robert Stone; Colorado State College—Ralph Wilson; Cornell—Jack Moulton; George Washington University—J. C. Ritter; Illinois—Robert H. McCarthy; Louisville—Rob-

A.S.M.E STUDENT BRANCH AT UNIVERSITY OF CALIFORNIA IN THE SPRING OF 1941

ert L. Gray; Missouri—Geitner Hibbeler; N.Y.U. (aeronautical)—Paul O'Meara; Ohio State—J. W. Schaefer; Rice—Vaughan B. Meyer; Texas A.&M. College—C. A. Lilly; Texas—A. D. Payne.

Another prize awarded at George Washington University was a paid-up Junior membership in the A.S.M.E. to Guy B. Watson through the generosity of the Washington D. C., Section of the Society.

A.S.M.E. Members at Michigan Win Baseball Game From S.A.E.

At the joint A.S.M.E.-S.A.E. Stag Picnic held on May 24 by the Michigan Student Branch, the mechanicals triumphed over the automotives by one run in the ninth inning. Refreshments were served during and after the game. All present agreed that the affair was successful and that similar ventures should be held in the fall.

Over 700 Attend Anniversary Reunion at Michigan College of Mining

More than 700 engineers and their wives attended the twenty-fifth anniversary reunion of Michigan College of Mining and Technology at Houghton, Mich., Aug. 7, 8, and 9, 1941. Michigan Tech, as it is known to its graduates, was established by the state as the Michigan Mining School. It became the Michigan College of Mines in 1897. In 1926, it expanded to its present size and scope, giving degrees not only in mining and metallurgy, but also in mechanical, civil, electrical, chemical, and geological engineering. Curricula in forestry and in general science have been introduced more recently.

Student Branch Secretaries

Please Note!

REPORTS of meetings and inspection trips must be received at Society Headquarters on or before the sixth of the month in order to appear in next month's issue of MECHANICAL ENGINEERING. For example, all copy received up to Oct. 6 will be in the November issue, etc.

PHOTOGRAPHS of student-member groups are always welcome for use in MECHANICAL ENGINEERING. Prints should be preferably glossy and of good contrast. However, send in everything you have and the editorial department will use those it can reproduce.

PUBLICITY is always good for the branch. Clippings from school and local newspapers should be sent in with your reports.

A.S.M.E. Student Group Meetings, 1941

GROUP I—NEW ENGLAND STUDENT MEETING, BOSTON, MASS., MAY 2–3, 1941

Attendance: 110 Papers presented: 11

Prize	*Recipient*	*Title of Paper*	*College*
First	SYDNEY LOW	"Design for and Investigation of Machine-Gun Mechanism Using Electric Ignition and Plastic Cartridge Cases"	Rensselaer
Second	F. S. WYLE	"Solving Engineering Problems With High-Speed Photography"	M.I.T.
Third	MILTON WALTCHER	"Air-Jacketing of Internal-Combustion Engine"	R. I. State
Old Guard	E. A. LEGROS	"Development of Humanistic Side of Engineering"	Brown
Fifth	THEODORE FOSTER	"The Integraph"	Syracuse
Sixth	E. P. NYE	"Effect of Load Variation on Throat Depression in Carburetors"	New Hampshire

GROUP II—EASTERN STUDENT MEETING, BROOKLYN, N. Y., APRIL 21–22, 1941

Attendance: 244 Papers presented: 16

Prize	*Recipient*	*Title of Paper*	*College*
First	D. M. POLLOCK	"Acoustic Velocity Wind Tunnel"	Pennsylvania
Second	W. A. HUNTER, JR.	"Dynamometer for Automobile-Performance Analysis"	Poly. Inst. Brooklyn
Third	L. J. HESS	"Oldsmobile Hydramatic Transmission"	Princeton
Old Guard	ARTHUR LESLEY	"Break-Point Chlorination"	Rutgers
Fifth	SABINUS CHRISTENSEN	"Following Stats With Electric Eye"	Pratt

GROUP III—ALLEGHENIES STUDENT MEETING, PITTSBURGH, PA., MAY 8–9, 1941

Attendance: 287 Papers presented: 8

Prize	*Recipient*	*Title of Paper*	*College*
First	CHARLES SHANK	"Psychology in Aviation"	Pittsburgh
Second	J. W. SCHAEFER	"Plastic Refractories"	Ohio State
Third	R. D. MATTINGLY	"Practical Device for Determining Heat Transfer by Conduction"	Maryland
Fourth	R. P. LATHROP	"Effect of Engineering in Public Affairs"	George Washington
Fifth	R. B. MCCURDY	"Mechanics of Drilling for Petroleum"	Akron

GROUP IV—SOUTHERN STUDENT MEETING, ATLANTA, GA., MARCH 30–APRIL 1, 1941

Attendance: 257 Papers presented: 15

Prize	*Recipient*	*Title of Paper*	*College*
First	G. W. GILMER, 3RD	"Yacht Sail Problem in Aerodynamics"	Florida
Second	B. E. LEWIS	"Locomotive of Tomorrow"	N. C. State
Third	W. F. HAMLIN	"New Continuous Pressure Cooker Oil-Expressing Unit"	Tennessee
Fourth	C. K. DILLINGHAM, JR.	"Development of Large Guns in United States"	Vanderbilt
Old Guard	H. R. HUGHES, JR.	"Field of Technical Writing"	Virginia

GROUP V—MIDWEST STUDENT MEETING, DETROIT, MICH., APRIL 14–15, 1941

Attendance: 184 Papers presented: 12

Prize	*Recipient*	*Title of Paper*	*College*
First	R. H. MCCARTHY	"Hot-Quenching of High-Speed Steel"	Illinois
Second	E. HANUSKA	"Exterior Ballistics"	Illinois Tech.
Third	D. M. HART	"Dimensional Growth of Cast Iron Due to Repeated Temperature Cycles"	Michigan State
Old Guard	W. M. ROHSENOW	"Engine Indicators"	Northwestern
Fifth	D. K. HART	"Torque-Load Relationships in Bolts"	Iowa State

GROUP VI—NORTH CENTRAL STUDENT MEETING, OMAHA, NEB., APRIL 25–26, 1941

Attendance: 112 Papers presented: 16

Prize	*Recipient*	*Title of Paper*	*College*
First	R. A. PEPPING	"Photoelastic Strain Gage"	Washington
Second	N. J. LINSTROMBERG	"Cooling-Tower Diagnosis"	Missouri

(*Continued on page 763*)

A.S.M.E. Student Group Meetings, 1941

(*Continued from page 762*)

Third	A. O. LEWEKE	"She Shook Herself to Pieces"	Missouri
Old Guard	R. B. WHITE	"Development of Elliptical Joukowsky Airfoils"	Kansas State
Fifth	H. F. BOTTCHER	"Porosity-Permeability Reading for Unconsolidated Sands"	Mo. Sch. Mines
Sixth	REUBEN GERLITZ	"Ah! Now I See It All"	N. D. State

GROUP VII—SOUTHWEST STUDENT MEETING, HOUSTON, TEXAS, MARCH 27–28, 1941

Attendance: 190 Papers presented: 16

Prize	*Recipient*	*Title of Paper*	*College*
First	ERNEST GRAVES	"Fluid-Metering Research"	Oklahoma
Second	B. H. AMSTEAD	"Characteristics of Hard-Facing Materials Used in Oxyacetylene Welding"	Texas
Third	M. C. SULLENDER	"Molded Plastic-Plywood Airplanes"	Rice
Fourth	W. F. FORD	"Effect of Octane Number on Internal - Combustion - Engine Performance"	Oklahoma
Old Guard	J. W. MANN	"Investigation of Properties of Absorbent Materials at Vapor Pressure Below 4.5 Mm"	So. Methodist
Sixth	W. E. BAUMAN	"Indicator for High-Speed Engines"	Texas Tech.
Seventh	W. D. HILBORN	"Synthetic Rubber"	Rice
Eighth	A. D. PAYNE	"Instrumentation Problems in Study of Steam Transmission Line Installations"	Texas
Ninth	F. M. MCCULLAR	"Sintered Bearings"	Texas A.&M.

GROUP VIII—PACIFIC NORTHWEST STUDENT MEETING, SEATTLE, WASH., APRIL 28–30, 1941

Attendance: 125 Papers presented: 10

Prize	*Recipient*	*Title of Paper*	*College*
First	H. I. CHATTERTON	"Transmission Dynamometer"	Washington
Second	F. B. MORSE	"Examination of Winter Gasolines"	Oregon State
Third	R. G. FOSTER	"Relation of High-Speed Factors in Efficiency in Hydraulic Reaction Turbine"	Washington
Fourth	WALTER THIEME	"Mechanized Forest-Fire Fighting Equipment"	Montana State
Fifth	T. A. MCLAREN	"Ship-Propulsion Problems"	British Columbia

GROUP IX—ROCKY MOUNTAIN STUDENT MEETING, DENVER, COLO., APRIL 17–18, 1941

Attendance: 81 Papers presented: 12

Prize	*Recipient*	*Title of Paper*	*College*
First	J. L. RONAYNE	"Economic Aspects of Octane Rating"	Colo. Sch. Mines
Second	R. W. HAMMOND	"High-Lift Devices for Airplanes"	Colorado State
Third	H. W. HICKS	"Purpose and Procedure of Oil-Well Acidizing"	Col. Sch. Mines
Fourth	J. J. SHILLING	"Necessity and Possibility of Having Engineers in Public Affairs and Executive Positions"	Utah
Old Guard	JOHN DYKES	"The Nomogram"	Wyoming
Sixth	STANLEY PROFFITT	"Postwar Mobilization of Industry"	Colorado
Hon. Mention	D. A. BERG	"Eccentrically Loaded Equal Angle Columns"	Utah

GROUP X—PACIFIC SOUTHWEST STUDENT MEETING, PASADENA, CALIF., APRIL 4–5, 1941

Attendance: 98 Papers presented: 12

Prize	*Recipient*	*Title of Paper*	*College*
First	E. G. STEPHENS, JR.	"Test of Double-Pipe Heat Exchanger"	Santa Clara
Second	H. P. HAYES	"Analysis of Flame-Hardening"	Santa Clara
Third	J. N. NIELSEN	"Panel Heating"	California
Old Guard	G. K. WOODS	"Performance Characteristics of Modified Mercury V-8 Engine"	California Tech.
Fifth	J. E. MILLER	"Luminescence of Living Organisms"	California

MODEL OF VISE BENCH IN SNOW

(Built by members of A.S.M.E. Student Branch of Michigan College of Mining and Technology for 1941 winter carnival.)

Notre Dame Students to Adopt Code of Ethics

IN the College of Engineering at the University of Notre Dame, the Dean meets with the senior engineers and architects weekly to discuss matters relating to their professional development after graduation. Because of the natural interest of the students on how the Selective Service System might affect their education, during the fall of 1940 the first few weeks were devoted to a thorough discussion of the parts of the Bill which dealt with college students. During this discussion the opportunity was taken to bring out the obligation which a citizen of the United States, particularly a male citizen, owes to his country, both in peacetime and in times of national emergency.

The lectures then turned to the type of work that a young man who has just received his degree in engineering or architecture might expect to be doing for the first year or two after graduation. The point was developed that a man after graduation may practice the profession of engineering in the special branch in which he pursued his studies during college, but all engineers are concerned very greatly with certain of the functional divisions of the profession. It is because they are able to apply their technical knowledge in some functional aspect of engineering that they become useful members of the engineering fraternity and earn a satisfactory livelihood during their professor careers.

Thus the obligation of the citizen, which was brought out in the discussion of the Selective Service System, and this broader view of engineering were utilized to lay the ground for a consideration of the obligations a young man assumes when he enters the engineering profession. This foundation occupied the first semester, the second-semester lectures were devoted to a consideration of professional ethics in the technical professions of engineering and architecture, but with some treatment of the ethics utilized by the other professions: law, medicine, ministry, and education. The lectures by the Dean are supplemented by several outside speakers—engineers of national repute with manufacturing companies, with public utilities, in consulting work, or in education.

Before considering the codes of ethics of the professional societies, several lectures were devoted to a consideration of the personal characteristics of the individual engineer or architect in his activities as a professional man, for

THE UNIVERSITY OF NOTRE DAME

THE CODE OF PROFESSIONAL ETHICS
of the
1941 Notre Dame Engineers and Architects

The Engineering Profession, as all other professions, must have a general but efficient standard of ethics if there is to be any unison between the practicing engineer and his neighbor. Moreover it is only proper that the young engineer should have a definite course to follow in his future relationships with clients and fellow professional men. Therefore, we, the graduating class of 1941 from the Engineering College of the University of Notre Dame, propose the following code as a guide along our selected path in life.

As young engineers we will:

1. Demonstrate honesty, sincerity, fairness, and honor in all of our professional dealings.
2. Abstain from all actions which, either directly or indirectly, would detract from the reputation, prospects, or professional undertakings of a fellow engineer.
3. Place our qualifications as engineers before the public in a dignified and conservative manner.
4. Consider information which concerns technical data, methods, or processes and business affairs, as well as all information which is not common public knowledge, to be strictly confidential and not within our rights to divulge.
5. Direct our actions toward the best interests of public welfare and supply our knowledge, skill, and training for the use and benefit of mankind.

FACSIMILE OF CODE OF PROFESSIONAL ETHICS ADOPTED BY NOTRE DAME STUDENTS

example, honesty, fair-mindedness, and the like. The relation of these professions to the nation and to society in general was also taken up in order to indicate that the engineer and architect has an obligation to forward the social welfare, in addition to maintaining a high professional integrity and keeping his technical accomplishments on a satisfactory level.

Several of the codes of professional ethics obtained from the national societies were discussed by the Dean item by item. Each item was analyzed to determine whether it was primarily concerned with professional relationships, personal characteristics, or the public interest.

It was early apparent to the seniors that the codes of professional ethics devised by the professional engineering societies are of greater value to men who have been in the practice of their profession for ten or more years than to the recent graduate. The seniors therefore were generally quite interested to devise a code of professional ethics for an engineer or an architect to guide him during the first five years after graduation. Each of the 85 seniors submitted such a suggested code. Ten or fifteen of these codes were selected at random for discussion in the senior lecture as to their probable effectiveness. The seniors then selected one man from each of the departments to constitute a committee which was to devise a single code of professional ethics that would, so far as possible, incorporate the best points of every code and at the same time would be a practical and working guide for the young engineer and architect immediately after graduation. The resultant code, which is here reproduced, was submitted to the senior class, and after slight modifications was adopted unanimously.

Missouri Branch Finishes Term With Picnic and Tug-of-War

THE last meeting of Missouri Branch for 1940-1941 was held on May 23 as a picnic at Rollins Spring, which is just south of Columbia, Mo. More than 60 members and guests attended. While one group played softball, another spent the time in pitching horseshoes. As darkness approached, hot dogs, iced tea, and ice cream were served. After everyone had finished eating, two of the faculty members each picked a team of student members and engaged in a tug-of-war. It is reliably reported that everyone had a wonderful time.

A.I.E.E. Issues Bibliography of Relay Literature

A "Bibliography of Relay Literature, 1927–1939" has just been published by the American Institute of Electrical Engineers. It contains 450 odd annotated references to the most significant articles published in the principal technical publications of the world from January, 1932, to December, 1939, and in A.I.E.E. Transactions and *Electrical Engineering* from January, 1927, through December, 1939. The bibliography may be purchased at A.I.E.E. headquarters, 33 West 39th St., New York, N. Y., at 25 cents per copy to members of the Institute and 50 cents per copy to nonmembers.

Research Fellowship on Fatigue of Metals

A RESEARCH fellowship on the behavior of metals subjected to Combined Fatigue Stresses is available for the 1941-1942 school year at Illinois Institute of Technology. This project is sponsored by the Welding Research Committee of the Engineering Foundation. The recipient will receive an annual salary of $650 and free tuition, spending one half time on the research project and the other on work for the M.S. degree. It is likely that the fellowship will be renewed for a second year. Applicants must have a B.S. degree in civil or mechanical engineering and each should submit a transcript of his scholastic record, two letters of reference, and statement of any special qualifications. Applications should be sent to Dr. Joseph Marin, department of civil engineering, Illinois Institute of Technology, Chicago, Illinois.

Illinois Tech Plans Airports Conference

AIRPORT construction, operation, and maintenance will be discussed by experts at a conference to be sponsored by Illinois Institute of Technology at the Palmer House, Chicago, Ill., October 30 and 31. It is planned to make the Conference an annual feature, balancing the annual Midwest Power Conference sponsored by the Institute each spring. Airport grading, drainage and paving, lighting and signaling, capacity and operations problems, airport layout, management, plane servicing arrangements, buildings, and fire protection will be among subjects discussed.

W. M. Selvey, Member of A.S.M.E., Heads Institute of Fuel, London

THE Council of The Institute of Fuel has announced that W. M. Selvey, member A.S.M.E., has been unanimously elected, and has agreed to accept the office of president of the Institute in succession to Lieut-Col. Sir John Greenly, as from October next. Mr. Selvey has been very closely identified for many years with the development of fuel economy in all forms but more particularly in connection with the electric power stations in this country and abroad.

At a recent meeting of the Council of The Institute of Fuel, it was unanimously decided to award the Melchett Medal for 1941 to Dr. Clarence A. Seyler, D.Sc., F.I.C., F. Inst. F., of Swansea, as some recognition of the research work on coal and its constitution that he has carried out and published for the benefit of the world at large over a period of many years.

(Continued on page 766)

A.S.M.E. STUDENT BRANCH MEMBERS AT C.C.N.Y., APRIL, 1941

IN YOUR PIPING SYSTEMS, TOO . . .

THE DANGER LIES AT THE **TURNS**

THE DANGER LIES AT THE **TURNS**

A "turn" in piping does not apply only to elbows and returns. The *changes in direction* occasioned by tees, reducers, laterals, nipples, etc., make them "danger spots" as well, because of the extra friction and strain imposed on the abrupt turns within them. *Play safe* with Tube-Turns at *every* danger point.

Protect the "danger points" in your piping with TUBE-TURN welding fittings

The job of controlling the terrific power and mechanical strain in racing cars is *doubly intensified* AT THE TURNS.

The most abuse, stress and wear in piping systems also occur *at the turns*—wherever there is a change in direction. Tube-Turns' exclusive construction—plus welding—insures the greatest possible strength, safety and leak-proof performance at these crucial points.

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TRADE MARK

Men and Positions Available

Send Inquiries to New York Office of Engineering Societies Personnel Service, Inc. This service is operated on a cooperative, nonprofit basis, whereby those actually placed in positions by the Service agree to contribute to help maintain this service

29 W. 39th St. New York, N. Y. | 211 West Wacker Drive Chicago, Ill. | 57 Post Street San Francisco, Calif. | Hotel Statler Detroit, Mich.

MEN AVAILABLE[1]

GRADUATE MECHANICAL ENGINEER, 46. Twenty years' experience general engineering design, installation, and service of varied machinery, including stokers, instruments, bearings; also sales engineering steam valves. Initiative, progressive. Prefer East. Me-685.

MECHANICAL ENGINEER proficient in internal-combustion engines, Diesel, electrical machinery. Oil burning, industrial and domestic. Marine tank-ship experience. Affable, exacting, thorough, capable, good producer. Prefer New York metropolitan location. Me-686.

MECHANICAL ENGINEER, 28, B.S.M.E., married. Five years design, construction, maintenance steam power plant and hydraulic pumping machinery. Capable of directing engineering, construction, maintenance work of similar nature. Now employed. Prefer Western location. Me-687.

MECHANICAL ENGINEER AND PURCHASING AGENT, M.E., with professional engineer's license. Eighteen years' experience: power plant, machinery manufacture, production, purchasing, export sales. Available because of war conditions. Me-688.

EXPERIENCED MECHANICAL ENGINEER as master mechanic, superintendent engineer, designer of special automatic machinery for wire, sheet metal, or ribbon stock or automatic machinery for secondary operations, drilling, milling, or assembly. Me-689.

MECHANICAL ENGINEERING EXECUTIVE, 48, many years' responsible experience organizing and operating purchasing and administrative functions. Wide knowledge of materials, having designed, purchased, inspected, and tested. Unusually wide knowledge of both government and private purchasing. Me-690.

EXECUTIVE, experience and training adaptable for handling subcontract work separate from regular organization. Full knowledge of systems, drawings, pattern machining. B.S. degree. Have managed machine shop and foundry. Me-691.

MECHANICAL ENGINEER, M.E. degree with over 17 years' intensive industrial experience covering production, costs, management including sale promotion. Now working as general manager of well-established woodworking concern. Desire greater opportunity for achievement. Me-692.

GRADUATE MECHANICAL ENGINEER, 27, desires change to responsible industrial or consulting position; New England preferred. Experience includes textile, southern pulp and paper industry, industrial control instrumentation. Me-693.

MECHANICAL ENGINEER, 29, married. Professional Engineer, N. Y. State. Eight years field and design experience steam power-plant equipment. Interested in engineering openings in Latin America. Fluent Spanish. Now employed. Me-694.

MECHANICAL ENGINEER, 41, married; executive, with experience in operation, design, construction, large petroleum refineries, modern processes, cracking, gas fractionation, polymerization, alkylation; have supervised 2000 men; could work in process industries or heavy chemicals. Now employed. Me-695.

[1] All men listed hold some form of A.S.M.E. membership.

POSITIONS AVAILABLE

PERSONNEL MEN, about 45, with heavy industrial experience. Should have engineering education, interviewing and employment work of manufacturing nature, and if possible, have worked in a machine shop. Location, New Jersey. Y-8776.

MECHANICAL ENGINEER who has had from four to six years' experience on the drafting board to assist in design of, and work with, the shop in production of a new machine. Should know machine-shop operation. Salary, $3120 a year. Location, New York, N. Y. Y-8782.

MECHANICAL ENGINEER who has had eight to ten years' experience covering heating and ventilating, particularly in respect to industrial processes, steam-power theory, and practice. As the work will be greatly diversified, it is probable that general industrial engineering would be of value. Salary, $3000–$3500 a year. Location, New Jersey. Y-8806.

EXECUTIVE ASSISTANT, 35–45, to the general master mechanic who has had steel-mill or similar experience. Graduate mechanical engineer preferred. He should be good at planning mechanical work and also estimating costs so that the figures can be placed in budgets. Applicant should be of type who will be capable of working up into position of general master mechanic. The work will consist of directing maintenance of entire plant, including rolling mills, tin mills, power plant, and shops. The maintenance department has over 1400 employees. Must be physically fit and American citizen. Future possibilities good. Salary, $3600–$7200 year. Middle West. Y-8807.

EXPERIENCED INDUSTRIAL ENGINEER, 30–40, with experience of appraisal of management and business trends, with good personality. Considerable detailed experience in time study, planning, and ordinary minutia of shop work is of less importance than an understanding of principle and alertness of mind. Must be able to write well, and have had some experience with engineering firms reporting on companies as a whole for bankers or investing groups. Headquarters, New York. Y-8813.

BUSINESS SPECIALIST, 25–55, to watch and study prices of industrial machinery, to arrange meetings of manufacturers of such machinery, to negotiate with manufacturers, to draw up voluntary price agreements and price ceilings, and to investigate costs of manufacture both generally and in individual cases. Duration, the emergency. Salary, $3200–$6500 a year. Location, South. Y-8822.

PUMP ENGINEER, mechanical, preferably 28–35, experienced in small rotary 20–200 gallon per minute industrial pumps, for design, patent research, contact with manufacturing units of company. Salary, $3000 a year. Location, New England. Y-8847.

PRODUCTION ENGINEER, 35–45, who has had experience in machine-tool operations for a plant working on job orders. Must be qualified to supervise production planning and scheduling; acquainted with processes and methods and capable of assuming responsibility. Some nonferrous foundry experience desirable. Permanent. Salary open. Connecticut. Y-8861.

MECHANICAL ENGINEERS, 27–38. (a) Man for the design and supervision of instruments such as pyrometers and recorders. (b) A man for layout of workshops for special plant fabrication. (c) A man for the design of plant conveyances. Give present and desired salaries, time able to start, and three references. $3600–$4800 year. Middle West. Y-8879-CDS.

PERSONNEL MAN as assistant to plant manager. Must have pleasing personality, natural ability to get along with employees, mature judgment, and experience in successful personnel work in handling union grievances and building employees' good will. May also be a safety director. South. Y-8881.

GRADUATE MECHANICAL OR INDUSTRIAL ENGINEER, 30–45, who has had some sales experience and is familiar with machine-tool operations. Duration, at least one year. $3000–$5000 year. New York State. Y-8886.

EXECUTIVE ENGINEERS, graduates preferred, 28–35, for positions in mail-order branches. Men with operating experience and proved executive ability with actual managerial experience in the handling of men and supervising of movement, warehousing, receiving, packing, and shipping of quantities of merchandise in large industrial or mercantile companies. $3500–$6000, depending on experience. Headquarters, Illinois. Y-8894-R282C.

DESIGNERS who have had considerable experience in internal-combustion engine design. Permanent. Salary, $3600 a year, plus overtime. Location, Connecticut. Y-8923.

ENGINEERS, 28–35, preferably graduates, with experience in buying or expediting, to work in purchasing department. Starting $3000–$3600 year. Ohio. Y-8932D.

SENIOR MECHANICAL DESIGNER with at least ten years' experience. He should preferably have had automotive or aeronautical gear experience and some experience on hydraulic devices. He will have charge of new development work on gear products. Permanent. Salary, $5000–$7000 year, depending on qualifications. Middle West. Y-8933-R304C.

FACTORY MANAGER, 40–50, who has had a well-rounded experience in the machine-tool field; must be capable director of organization personnel and know all production problems of a large medium-weight-machine manufacturing plant. Will be responsible for an entire plant employing about 700 men. Permanent. Sal-

(*Continued on page 768*)

WE RENEW OUR PLEDGE

Two years ago, at the beginning of the present war with its uncertainties and threats to the future of all industry, this Company publicly pledged itself not to increase its selling prices.

On this, the second anniversary, we again publicly renew that pledge.

During the last two years we have not only kept the pledge previously made, but *we have actually reduced our selling prices by more than 6%* because of more efficient operation made possible by the marvelous cooperation and ability of our organization. This was accomplished in the face of rising labor and material costs, both of which have been increased by considerable amounts.

It is our belief that the only hope for the continuance of the present industrial system now threatened from within and without is in its ability to give more and more to the consumer for less and less of his dollar. This is the strength of American individual initiative. This is the hope of our country's future. If American industry can accomplish this universally, we need not fear dictators either at home or abroad.

THE LINCOLN ELECTRIC COMPANY

Cleveland, Ohio
October 2, 1941

J. F. Lincoln
President